

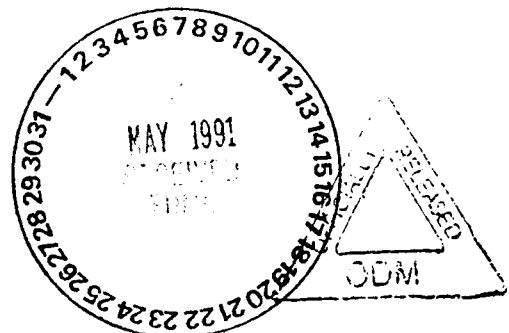
UNCLASSIFIED

PROCESS FLOWSHEET  
DEMONSTRATION OF NEUTRALIZED CURRENT ACID WASTE  
PRETREATMENT AT B PLANT

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WASTE MANAGEMENT SEPARATIONS PROCESS TECHNOLOGY

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## 1.0 INTRODUCTION

This flowsheet supports the demonstration processing of neutralized current acid waste (NCAW) at B Plant for separation of transuranic (TRU) bearing solids and cesium from the supernate. The demonstration is to be performed beginning in October 1990, with full-scale production commencing in June 1991. A process test of the NCAW settle/decant and polishing filter operations has been performed at B Plant. Results from this process test, as well as extensive laboratory and pilot plant tests, were used as the basis of this demonstration flowsheet.

The need to process NCAW to separate the TRU bearing solids from the supernate is based on the excessive cost of sending the entire waste stream to the Hanford Waste Vittrification Plant (HWVP). The TRU content and heat generation rate of the NCAW slurry is too high to allow this waste stream to be sent directly to grout. Sending the NCAW directly to vitrification is also undesirable, since the soluble salts would create approximately eight times as many glass canisters as the TRU bearing solids alone.

Cesium is to be removed from the supernate stream for inclusion in glass. This decreases the heat and radiolytic loading in grout and removes a fission product with a relatively long half life. The separated cesium will be stored in B Plant until HWVP startup. This will maintain the option for encapsulation of the cesium should a need develop for cesium capsules in the interim.

The objectives of the NCAW pretreatment process in B Plant are to:

- minimize the amount of soluble salts going to glass
- separate TRU solids to assure that grout produced from the liquid fraction will not be classified as a TRU waste
- assure soluble components which are of concern to HWVP processing or performance meet specific separation limits
- separate cesium and insoluble fission products from the supernate to meet grout design basis limits

The NCAW pretreatment process uses settle/decant unit operations for the primary solid/liquid separation and solids washing steps. Polishing filtration to further clarify the decant streams is accomplished with a sintered metal filter and a diatomaceous earth filter aid. Cesium removal is performed by ion exchange on an organic resin and the concentrated cesium stream stored in B Plant. A TRU solids stream and a low-level waste stream are sent from B Plant to the tank farms.

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Calculations for the material balance, batch sizes, cycle times, and essential materials used for this flowsheet were performed on a computer spreadsheet. The spreadsheet is documented in Reference 1, with the assumptions used included in Appendix 1 and 2. In the spreadsheet, assumptions and calculations are given and cross referenced for legibility. The assumptions may be changed to observe the effects throughout the process as the spreadsheet is recalculated. The use of the spreadsheet also allows graphical portrayal of the process variations. This computer process simulation will be available for use as a continuing process control and analysis tool for NCAW processing at B Plant.

## 2.0 PROCESS SUMMARY

Current acid waste (CAW) is produced by the PUREX process as the waste stream from first cycle solvent extraction in the PUREX plant. This waste stream contains most of the fission products and americium from irradiated fuel, corrosion products, iron and sulfate from the ferrous sulfamate reductant used in the PUREX process, and trace amounts of plutonium. The CAW is partially denitrated by addition of sucrose, then "neutralized" to a pH of approximately 14 by adding sodium hydroxide. The neutralized CAW (NCAW), is then sent to interim storage in double-shell carbon steel underground tanks.

The NCAW will be retrieved from TK-101-AZ for the demonstration process at B Plant. The current retrieval plans call for the retrieval of approximately 380,000 L (100,000 gal) of NCAW for the demonstration period. The NCAW will be transferred from AR Vault to B Plant in 53,000 L (14,000 gal) batches.

The NCAW pretreatment process in B Plant is illustrated in Figure 2-1. The major unit operations are solid/liquid separation and washing, polishing filtration, cesium removal by ion exchange, and concentration of the cesium and low-level waste streams.

In B Plant, primary solid/liquid separation will be accomplished by gravity settling of the NCAW solids followed by decantation of the supernate. Two sets of tanks operating independently will be used for the settle/decant process. The purpose of using a set of tanks is to allow concurrent settling of feed and wash slurries in separate tanks to minimize overall cycle times. Each set of settling/decant tanks includes a primary tank and two wash tanks.

Projections for a high solids waste, such as may be encountered during production processing of NCAW from TK-101-AZ, show two sets of tanks would process the first tank of waste in about one and one-half years. Assuming the production processing begins by July, 1991, this should provide treated TRU solids in a time frame to support characterization for the HWVP program. There are no process rate constraints currently set by tank farm space availability (Reference 2).

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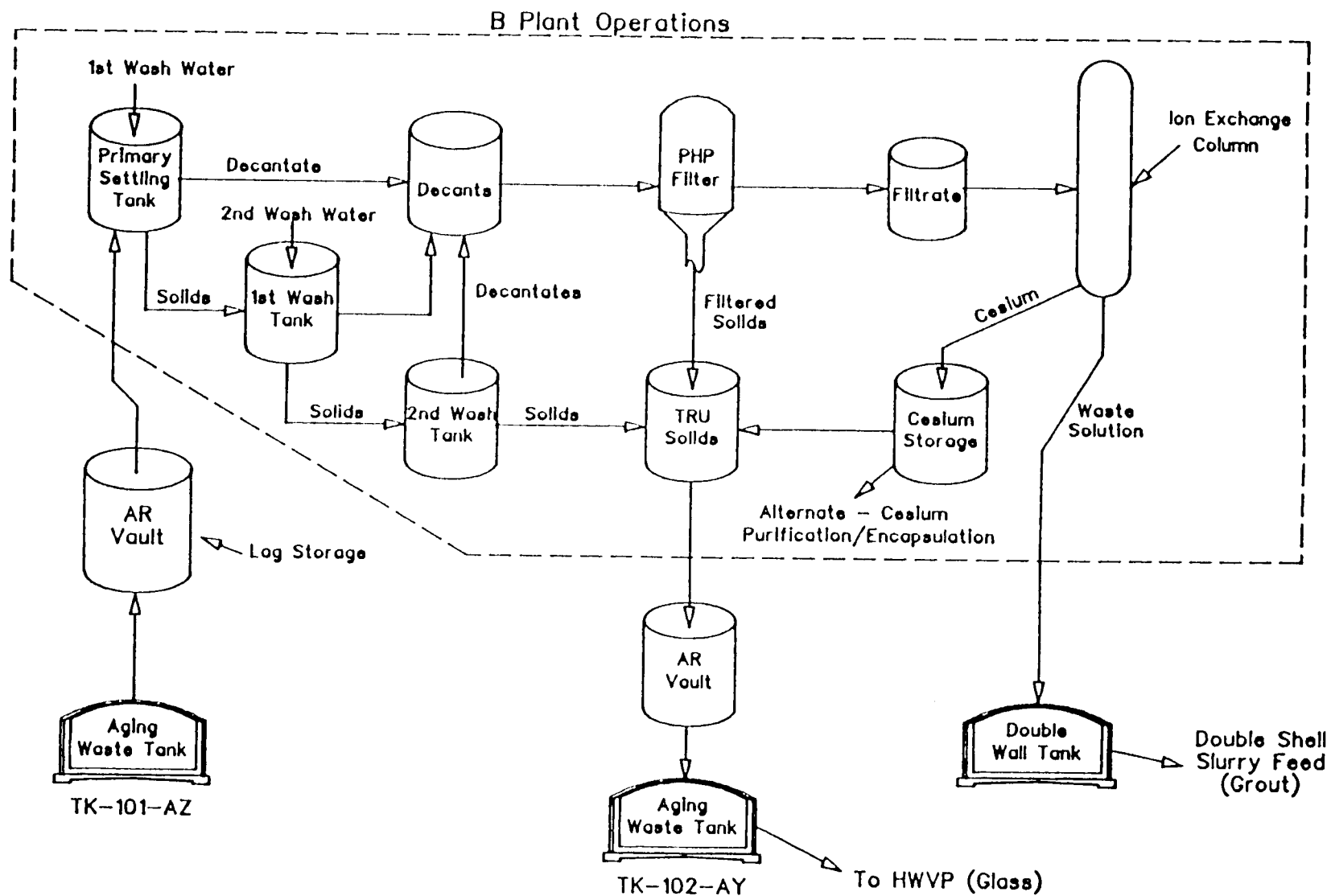


Figure 2-1. Schematic of B Plant NCAW Pretreatment Flowsheet

The settle/decant process includes two washes of the solids to further dilute and remove soluble salts that remain in the interstitial liquor of the settled solids. The two washes at a 3:1 water to settled solids volume ratio provide more dilution than a single 15:1 wash. The overall wash dilution must be equivalent to a 15:1 wash or greater, based on sludge washing studies (References 3 and 4) and on calculated dilutions required to meet soluble salt limits in the glass feed stream.

A flocculating agent, ferric nitrate, will be added to the feed batch after it is transferred into the first tank in each set of tanks used. This agent will enhance settling rates, maximize throughput, and also contribute to improved supernate clarity.

The settle/decant process continues as the solids are settled in a primary settling tank, then the supernate decanted and routed to the polishing filter feed tank. Wash water will then be added to the settled solids in the primary tank, and the slurry transferred to the first wash settling tank. Once the settling period is complete in the first wash tank, the supernate will be decanted to the polishing filter feed tank, and a second wash water addition made. After transfer to the second wash settling tank and completion of the second wash settling period, the second wash decant solution will also be sent to polishing filtration. A slurry water addition will then be made to the second wash tank so that the settled solids can be jetted out and eventually returned to the underground storage tanks.

Polishing filtration will be performed on the primary and wash decantates by the pneumatic hydropulse (PHP) filter. The filter is used in an inverted mode, with the solids cake collected on the inside of the filter. The solids cake then can be dislodged by an air pressure driven liquid backpulse and collected in a tank directly below the filter. A filter aid, diatomaceous earth (DE), is used to precoat the filter before a feed cycle, and also is added to the feed at a 1:4 DE to feed solids weight ratio. The DE acts to prevent plugging of the sintered metal filter by the fine, compressible NCAW solids, and to create a more porous cake buildup that allows longer cycle times between backflushes.

When the PHP feed batch has been processed, the feed pump is shut off, the filter backpulsed using air pressure, and the solids removed. These solids are combined with the washed solids from the settling process, and sodium hydroxide and sodium nitrite additions are made as required to meet tank farm corrosion specifications. The solids slurry is transferred back to tank farms through AR Vault in 13,900 L (3,660 gal) batches, followed by a 10,070 L (2,660 gal) line flush.

The filtrate from the PHP filter is sent to the feed tanks for the ion exchange (IX) process. A Duolite CS 100 (trademark of Rohm & Haas) resin in the sodium loaded condition is used to remove more than 94% of the cesium from the feed stream by means of two IX cycles, while adsorbing smaller percentages of the sodium, potassium, rubidium, and aluminum. The feed batch to the first cycle IX process is about 112,000 L (29,600 gal) and must be fed continuously. A sodium scrub using 0.1 M nitric acid then removes most of the sodium on the ion exchange column, followed by a cesium elution with 0.3 M nitric acid that removes the cesium from the column. Finally,

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the resin is regenerated back to the sodium loaded condition with sodium hydroxide. All streams are fed to the IX column downflow, except for the sodium hydroxide regeneration and regeneration flush streams which are fed upflow.

Before the second IX cycle is performed, the acidic cesium eluate stream from the first IX cycle is concentrated (to minimize the volume requiring lag storage) and neutralized by a sodium hydroxide addition. The Duolite CS 100 resin requires a basic feed stream for effective cesium adsorption. The second cycle ion exchange process then follows the same steps as the first cycle. The final cesium stream is concentrated and stored in the acid form in B Plant.

The second cycle of ion exchange is required to further separate the cesium from sodium. The amount of sodium must be reduced to allow concentration of the cesium to a small enough volume for long term storage within B Plant. A further reason for the second IX cycle is that after eventual combination of the cesium stream with the NCAW solids for processing into glass, excessive sodium would contribute to higher glass volumes and disposal costs.

The waste streams from the first and second IX cycles are sent through the low-level waste concentrator before transfer out of B Plant directly to the tank farms for interim storage. Since there are only 47,600 L (12,570 gal) of lag storage between the IX column and the low level waste concentrator, the concentrator must operate continuously in conjunction with the IX column. The low level waste is concentrated to 5.0 M sodium, sampled, and sent to the tank farms. The sodium scrub and regeneration batches are processed in the same manner.

### 3.0 PROCESS DESCRIPTION

The process vessels and streams identified in the process description below are illustrated in Figure 3-1 and in the flowsheet schematics and batch transfer diagrams in Section 11. Relationships of the batches between the settle/decant operations, PHP filter, and ion exchange/concentrator operations are shown in Figure 3-2.

#### 3.1 RECEIPT AND STORAGE OF NCAW FEED

The NCAW will be retrieved from aging waste TK-101-AZ, according to the retrieval process flowsheet for the demonstration in Reference 5. The composition of NCAW in TK-101-AZ is taken from References 6 to 8, and is given in Table 3-1 below.

The NCAW will be received in 53,000 L (14,000 gal) batches from AR Vault. The NCAW is initially received in TK-11-2. As the transfer proceeds, the solution is jetted from TK-11-2 to both TK-8-1 and TK-9-2. A further transfer from TK-8-1 to TK-8-2 is also required to accommodate the entire transfer batch. At the completion of the transfer from AR Vault, the two

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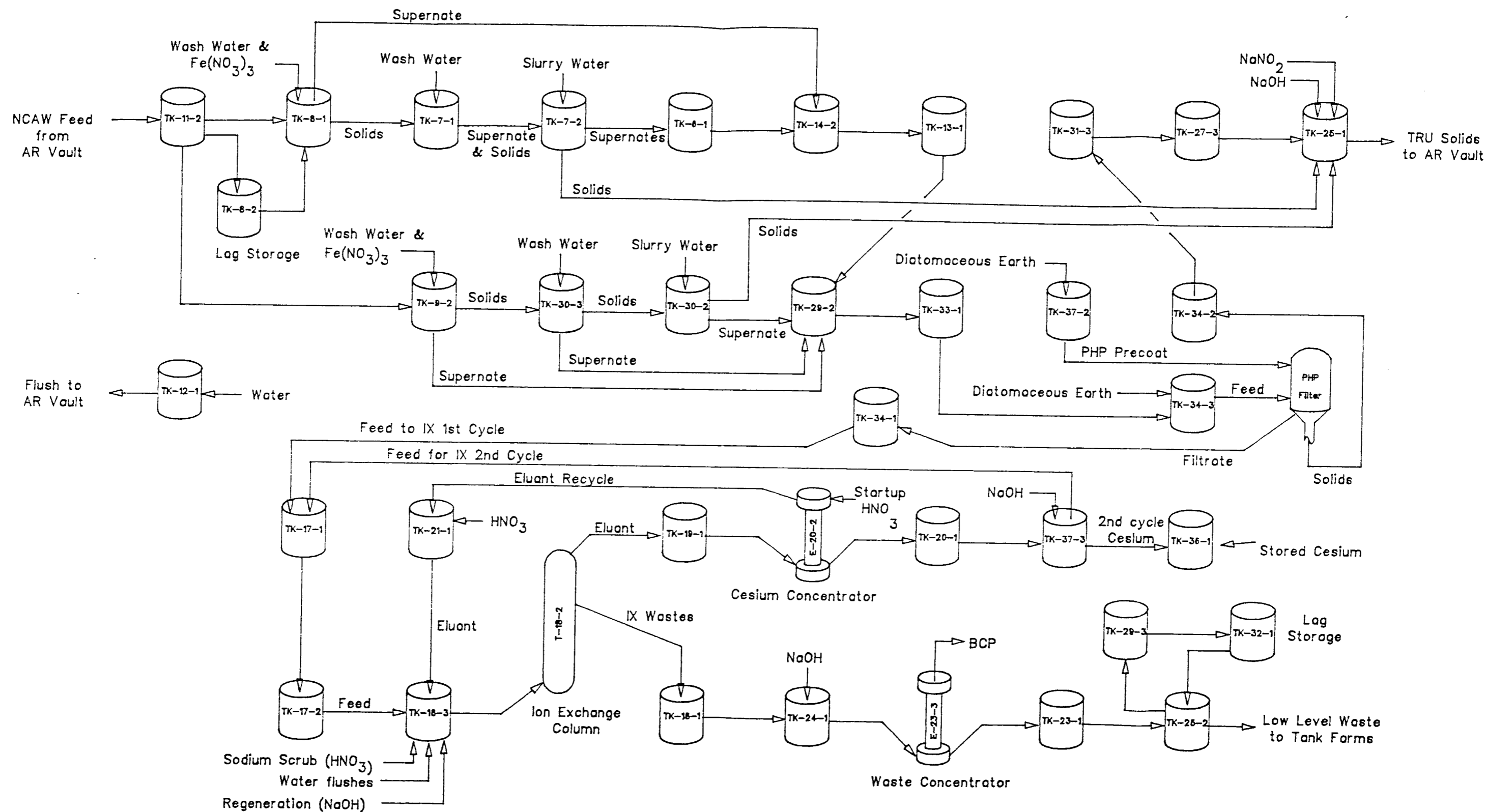


Figure 3-1. Overall Process Routings (See Figure 11-1 for details)

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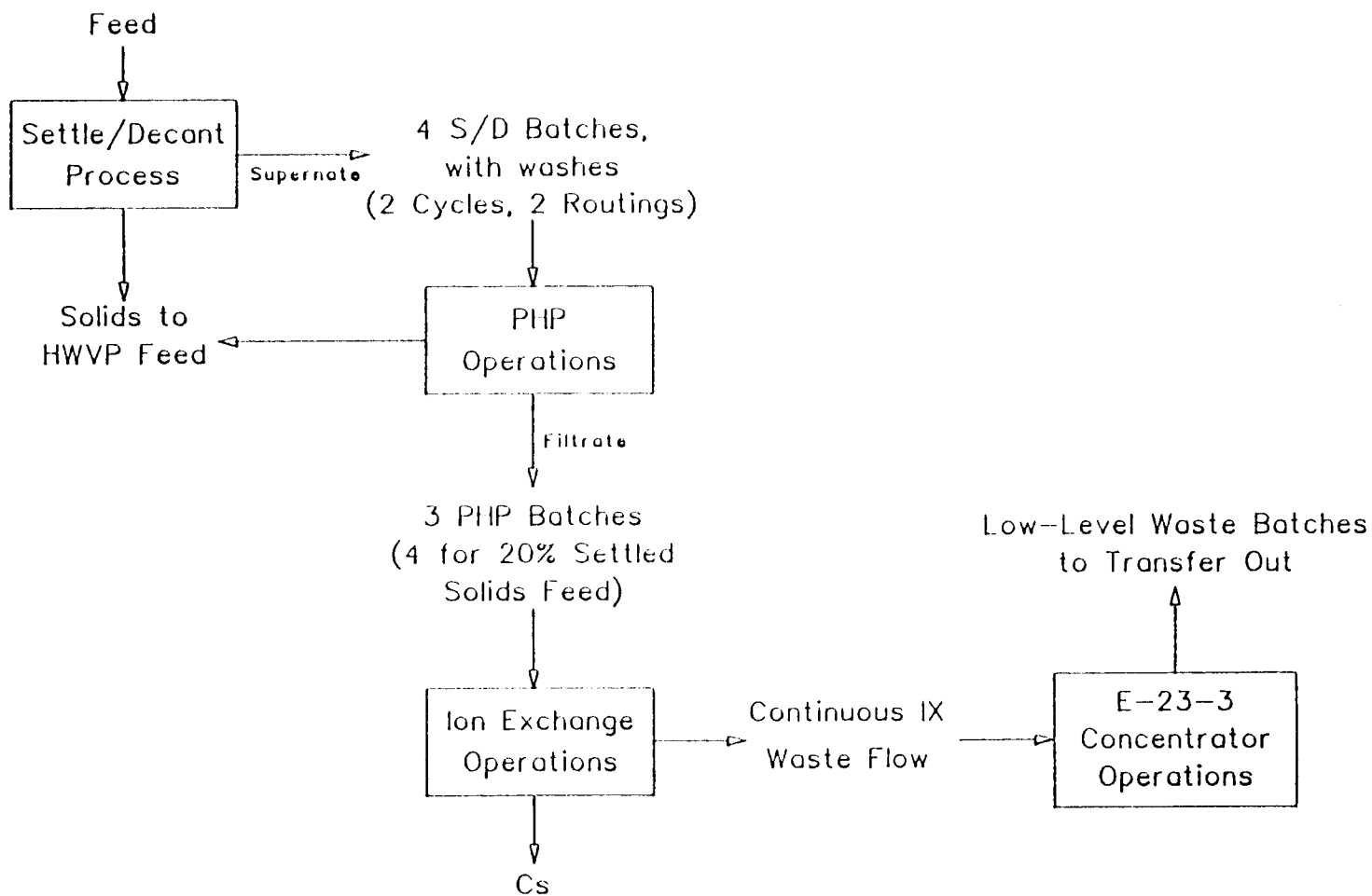


Figure 3-2. Unit Operations Batch Relationships

Table 3-1. Composition of NCAW Feed to B Plant  
(From References 6, 7, & 8)

Component	Supernate <u>M</u>	Total Slurry <u>M</u>
pH	13+	
sp. gr.	1.17	1.20
OH (Free OH)	1.1	1.0
PO <sub>4</sub>	<0.028	<0.025
SO <sub>4</sub>	0.15	0.15
NO <sub>3</sub>	1.8	1.7
NO <sub>2</sub>	0.44	0.43
CO <sub>3</sub>	0.21	0.23
TOC (as C)	0.047	0.14
Na	4.9	5.0
Al	0.48	0.50
K	0.12	0.12
Rb	1.1 E-04	1.1 E-04
Cs	6.3 E-04	6.3 E-04
Ca	2.6 E-04	0.016
Ru	2.1 E-04	2.1 E-04
Cr	0.011	0.012
Pb	4.0 E-04	6.3 E-04
Mg	5.0 E-05	6.9 E-03
Mo	9.0 E-04	1.1 E-03
P	0.017	0.022
Si		0.060
Zr		0.044
Ba		8.4 E-04
B		6.8 E-03
Cd		6.0 E-03
Ce		1.4 E-03
Co		7.0 E-05
Cu		3.7 E-04
La		8.4 E-04
Mn		1.9 E-03
Nd		1.3 E-03
Ni		8.2 E-03
Pd		0.011
Ag		1.3 E-04
Sr		4.2 E-04
Ti		2.0 E-04
Zn		4.8 E-04
Fe		0.067
F	0.089	0.087
Cl	<0.009	<0.008

Table 3-1. Composition of NCAW Feed to B Plant (Continued)  
(From References 6, 7, & 8)

Component	Supernate	Total Slurry
Total Beta (micro Ci/L)	3.1 E+06	2.0 E+07
<sup>90</sup> Sr (micro Ci/L)	2.0 E+02	9.1 E+05
<sup>239</sup> Pu (g/L)		2.6 E-03
<sup>241</sup> Am (g/L)		2.6 E-03
<sup>99</sup> Tc (micro Ci/L)	2.0 E+03	1.2 E+04
U (g/L)	<0.0049	0.94
GEA (micro Ci/L)		
<sup>134</sup> Cs	1.1 E+05	1.1 E+05
<sup>137</sup> Cs	2.2 E+06	2.2 E+06
<sup>226</sup> Ra	1.1 E+04	1.5 E+04
<sup>106</sup> Rh/Ru	4.1 E+04	1.1 E+06
<sup>103</sup> Ru	2.4 E+03	1.9 E+04
<sup>95</sup> Nb		6.9 E+05
<sup>95</sup> Zr		3.3 E+05
<sup>144</sup> Ce/Pr		9.6 E+06
<sup>155</sup> Eu		6.2 E+04
<sup>125</sup> Sb		1.2 E+05

Volume: 1,453 L/MTU in TK-101-AZ

Note: Unreported OH- assumed to account for  
overall charge balance

primary settling tanks in each routing are full, ready to initiate a settling cycle. The two lag storage tanks, TK-11-2 and TK-8-2, are also full so that both settle/decant routings have a feed batch in reserve.

A water flush of 10,100 L (2,660 gal) is sent from TK-12-1 through a diaphragm operated valve back to AR Vault following the transfer. The flush to AR Vault must be started within 15 minutes of the completion of the slurry transfer to B Plant to prevent solids from settling in the transfer line.

### 3.2 SETTLE/DECANT FOR PRIMARY SOLID/LIQUID SEPARATION

Settling in the cell 7/8 settling tank set or train is described below, but the sequence of operations applies to any settling train established in the plant for concurrent settling. The settling process in continuous operations will have a batch of washed slurry settling in each of the two wash tanks, TK-7-1 and TK-7-2, as the primary tank feed is transferred into the primary settling tank, TK-8-1. The primary tank feed batch size is 15,100 L (4,000 gal).

A 379 L (100 gal) batch of the flocculating agent, ferric nitrate at a 0.023 M concentration, is added to the primary tank and mixed well, then the tank agitation is turned off. While the primary tank is settling, the second wash tank settling is completed and the wash decantate removed. The batch size for the second wash decantate is 5,520 L (1,460 gal), as it is jetted to TK-6-1, and subsequently through TK-14-2, TK-13-1, and TK-31-1 to TK-33-1.

Slurry water is then added to the second wash tank in a 350 L (90 gal) batch, and the agitator turned on. The solids slurry batch, 2,119 L (560 gal) is transferred from the second wash tank, TK-7-2, to TK-25-1. A flush of 379 L (100 gal) is added to the second wash tank to minimize solids heels that might contaminate the first wash decant which must subsequently be routed through the second wash tank. The flush is transferred out to TK-25-1 and combined with the solids slurry.

The first wash decant is then transferred out of TK-7-1 through TK-7-2 enroute to the PHP filter, in a 5,520 L (1,460 gal) batch. A second wash water addition of 5,020 L (1,330 gal) is made and the slurry agitated and transferred to TK-7-2 where the second wash settling is started. The slurry batch size is 7,027 L (1,857 gal).

At this point, the primary tank settling proceeds to completion. The primary decantate, 14,300 L (3,770 gal) is jetted out from TK-8-1 to TK-14-2. From TK-14-2 it is jetted through TK-13-1 and TK-29-2 to be combined with the wash decantates in TK-33-1 as feed for the pneumatic hydropulse filter. The decantates are sampled in TK-33-1 for process control of both TRU and solids content before feeding to the PHP filter.

The first wash water addition of 5,020 L (1,330 gal), is made to the primary tank and the agitator turned on. The solids slurry is then transferred to the first wash tank and settling initiated there. This completes the steady state operations cycle for the settling tanks, as the primary settling tank is now ready to receive another batch of feed.

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### 3.3 PNEUMATIC HYDROPULSE FILTER FOR POLISHING FILTRATION

The pneumatic hydropulse filter is operated for a loading cycle based on the filtrate rate from the filter and a batch size of 34,250 L (9,050 gal). The PHP filter operations are computer controlled to provide smooth feed rate ramp-up and transition between the precoat and feed solutions so that a consistent filter cake is maintained.

Prior to the start of a loading cycle, a precoat of diatomaceous earth is applied to the PHP in a batch of 1,140 L (300 gal) pumped from TK-37-2 to the filter. The precoat is a coating of diatomaceous earth placed on the sintered metal filter element prior to starting the feed cycle. This coating helps prevent fouling of the filter element.

The diatomaceous earth precoat solution will be made up in five batches in scale tank TK-39A (capacity 284 L, [60 gal]) to provide the total precoat batch of 1,140 L (300 gal). The diatomaceous earth is added at a ratio of 0.58 kg (1.3 lb) per 284 L (60 gal) of solution, for transfer to TK-37-2. Continuous agitation of the precoat solution is important to prevent settling of the diatomaceous earth, and possible tank solids buildup.

A body feed is also used in the process. Diatomaceous earth added to the feed stream helps prevent compaction of the solids cake as it builds up on the filter element, and enhances the filtrate flow through the cake, thus prolonging the cycle length. The body feed of diatomaceous earth is added from scale tank TK-34-3A, where 2.0 kg (4.4 lb) of diatomaceous earth have been mixed into 380 L (100 gal) of water. The body feed is added to TK-34-3, agitated for 0.5 hour, and the feed pumped to the PHP. When the complete batch has been fed to the filter, the feed and filtrate valves are shut off, and the backwash cycle is started.

The backwash cycle begins by opening a valve on the PHP filter shell side to pressurize with air, then closing the valve to a minimum air flow (to prevent a vacuum as the solids slurry exits). A ball valve on the bottom of the filter is then quickly opened, allowing the sudden pressure differential to dislodge the solids cake and dump it into TK-34-2 on which the PHP is mounted. The air valve is then closed. The volume of the solids slurry is 130 L (34 gal). Solids from five cycles of PHP operation will typically be collected in TK-34-2 before the solids are transferred to TK-25-1 via TK-27-3 to be combined with the settle/decant process solids and sent to tank farms. Agitation in TK-34-2 and TK-31-3 must be maintained to prevent solids from settling.

The filtrate from the PHP is collected and sampled in TK-34-1. The volume from a loading cycle is 35,250 L (9,310 gal). This solution is transferred into TK-17-1 and TK-17-2 as it is processed through the PHP filter. These tanks are used for lag storage, until the filtrate can be sent to the IX process via TK-18-3.

### 3.4 ION EXCHANGE FOR CESIUM REMOVAL - FIRST CYCLE

The total ion exchange feed batch size is 112,000 L (29,600 gal) based on the total tank capacity for lag storage between the settle/decant operations and the IX column. A continuous loading onto the column is desirable to minimize the time the resin is loaded with cesium. This should reduce the radiolytic degradation of the resin. The activity loaded on the column for the first cycle is 100,000 Ci of cesium-137. Loading waste from

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the IX column feed is collected in TK-18-1, then transferred to TK-24-1 as E-23-3 Concentrator feed. The feed rate to the IX column (fed downflow) should be approximately 30 gpm to best match PHP, IX, and concentrator operations.

After the first IX cycle feed batch has been completed, or cesium breakthrough is indicated by the gamma monitor on the column effluent stream, a water flush of 13,250 L (3,500 gal) is sent through the column to TK-18-1 to displace the remaining feed solution from the column. This will reduce the reaction in the column between any residual basic feed solution and the upcoming acidic sodium scrub solution. When the concentrator has completed processing the loading waste and flush, feeding of the sodium scrub stream to the IX column can be initiated.

The sodium scrub solution is 0.1 M nitric acid, made up from 1 M nitric acid in TK-MO-154 which is reduced to 0.1 M by in-line water dilution, and then added through TK-18-3 to the column. The batch size is 56,300 L (14,900 gal). This solution is collected in TK-18-1 and transferred into TK-24-1 for feed to the E-23-3 Concentrator. An addition of 310 L (80 gal) of 19 M NaOH is needed to neutralize the scrub before concentrating. Due to the large batch size, the concentrator must process the scrub as it is fed from the IX column.

The 0.3 M nitric acid cesium eluant from TK-21-1 is sent to the column after the sodium scrub solution, via TK-18-3. The total amount fed is 53,000 L (14,000 gal). A portion of the  $H^+$  in the acid is lost from the eluant as it exchanges onto the IX resin for the cesium and other cations eluted from the resin. The eluate is collected in TK-19-1, and sent to the E-20-2 Concentrator, which operates in a recycle mode to provide a 0.22 M nitric acid overhead back to TK-21-1. A batchwise make-up stream of 12.2 M nitric acid (approximately 220 L or 60 gal) must be added into TK-21-1 to result in the above-mentioned 0.3 M nitric acid eluant that is sent the column. The concentrator is started with the pot containing 4.2 M nitric to establish proper operating conditions before the eluant feed to the IX column begins. An eluant flush of 26,500 L (7,000 gal) of water follows the elution step. The first 7,600 L (2,000 gal) of this flush is sent to TK-19-1 and the E-20-2 Concentrator. The remainder is routed to TK-18-1 and the E-23-3 Concentrator.

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A sodium hydroxide regeneration solution is sent to the IX column to return the resin to the sodium loaded form after the cesium elution flush is complete. The volume is 19,900 L (5,250 gal) total, but the solution is sent in two batches, first a batch of 6,600 L (1,750 gal) at 0.5 M sodium hydroxide concentration, followed by a 13,250 L (3,500 gal) batch of 2.0 M sodium hydroxide. The regeneration is followed by a 6,600 L (1,750 gal) regeneration water flush, leaving the column ready for the next loading cycle. These streams are collected in TK-18-1 and transferred to TK-24-1 for concentrator feed.

The regeneration and regeneration flush streams are the only process streams feeding the IX column, both for first and second IX cycles, that are fed upflow. The regeneration stream is fed upflow to minimize the effects of the expansion of the IX resin. The regeneration flush is fed in like manner to "fluff" or redistribute the IX resin bed in order to prevent channeling and early breakthrough before the addition of the next IX feed batch.

### 3.5 CONCENTRATION OF CESIUM STREAM - FIRST IX CYCLE

Concentrator operations in E-20-2 must be sustained as the ion exchange elution process is ongoing, as there is not sufficient lag storage space for the entire cesium eluant and eluant flush streams. The feed volume will be reduced by a factor of about 55, as the solution is concentrated to 2.5 M sodium. This will be correlated during demonstration with a given specific gravity so that the process may eventually be run by monitoring specific gravity rather than by volume. The total feed for a first IX cycle is 60,600 L (16,000 gal), with a product volume of 1,100 L (290 gal) expected.

### 3.6 ION EXCHANGE FOR CESIUM REMOVAL - SECOND CYCLE

The concentrated cesium solution from the first IX cycle is collected in TK-20-1 and routed to TK-37-3 as concentration operations proceed. The total volume is 1,100 L (290 gal). In TK-37-3, a sodium hydroxide addition of 380 L (100 gal) of 8.8 M caustic is added to make the solution basic with a pH of 13 for feeding to the second IX cycle. The concentrated first cycle cesium product solution is then stored in TK-37-3. When TK-20-1 and TK-37-3 are filled (approximately eight first cycle product batches), the second cycle loading will begin.

The second IX cycle proceeds in the same sequence described for the first cycle. The second IX loading will be  $7.8\text{E}+05$  Ci of cesium-137. The volumes for the various streams at this loading limit are:

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Feed batch	- 12,500 L (3,300 gal)
Loading Waste	- 12,500 L (3,300 gal)
Feed Flush	- 13,250 L (3,500 gal), demineralized water
Sodium Scrub	- 36,400 L (9,600 gal), 0.1 <u>M</u> nitric acid
Cesium Eluant	- 39,700 L (10,500 gal), 0.5 <u>M</u> nitric acid
Eluant Flush	- 26,500 L (7,000 gal), demineralized water
Regeneration	- 6,600 L (1,750 gal), 0.5 <u>M</u> NaOH
	- 13,250 L (3,500 gal), 2.0 <u>M</u> NaOH
Regen. Flush	- 6,600 L (1,750 gal), demineralized water

The waste streams from the second IX cycle are collected in TK-18-1 and routed to TK-24-1 for concentration. A NaOH addition of 380 L (100 gal) 19 M solution is required to neutralize the sodium scrub before it is concentrated.

### 3.7 CONCENTRATION OF CESIUM STREAM - SECOND IX CYCLE

Operations for the second IX cycle are similar to those for the first IX cycle, except that the feed to the E-20-2 Concentrator is concentrated to 5 M sodium. The feed volume will be reduced by a factor of about 110, with a total feed stream of 47,300 L (12,500). The final concentrated cesium stream is 425 L (110 gal) per batch, before transfer from TK-20-1 through TK-37-3 to the storage tank, TK-36-1. At a final batch volume after jet dilutions of 450 L (120 gal), TK-36-1 will store the cesium from processing about 4.8 million L (1.3 million gal) of NCAW feed to B Plant.

### 3.8 CONCENTRATION OF LOW-LEVEL WASTE STREAM

The E-23-3 Concentrator feed batches for first and second cycle IX operations are given below.

First IX cycle feed/flush batch	125,000 L (33,000 gal)
First IX cycle scrub batch	56,600 L (15,000 gal)
First IX cycle regeneration/flush batch	45,400 L (12,000 gal)
Second IX cycle feed/flush batch	25,800 L (6,800 gal)
Second IX cycle scrub batch	36,800 L (9,700 gal)
Second IX cycle regeneration/flush batch	45,400 L (12,000 gal)

The concentrator will need to run continuously to support the IX column operations, specifically the feed batch and the sodium scrub, since there is not enough lag storage between the concentrator and the IX column to hold an entire batch of these solutions. The wastes will be concentrated to 5 M sodium. The concentrated wastes are collected in TK-23-1, and transferred to TK-25-2. TK-25-2 is sampled to assure tank farm corrosion and grout product specifications are met.

The total condensate from the E-23-3 Concentrator operations is 259,000 L (68,400 gal) from concentration of the low-level wastes from the first and second IX cycles.

### 3.9 LOW-LEVEL WASTE STREAM TRANSFER OUT

Low-level waste transfers are made through TK-25-2 to the tank farms after sampling has verified that the hydroxide and nitrite levels meet the corrosion prevention criteria for the double-wall tanks. B Plant Operating Specifications for TRU and specific fission product concentrations for the grout feed stream must also be met. The transfer batch volumes are as follows:

First IX cycle feed/flush batch	44,000 L (11,600 gal)
First IX cycle scrub/regeneration/flush	5,300 L (1,400 gal)
Second IX cycle wastes	15,000 L (4,000 gal)

### 3.10 TRANSURANIC SOLIDS SLURRY TRANSFER OUT

The transuranic solids stream in TK-25-1 requires additions of sodium nitrite and sodium hydroxide to meet tank farm corrosion specifications. The solid slurry batches from four cycles of settle/decant/PHP operations may be stored in TK-25-1 before adding these solutions. The additions for this case would be 380 L (100 gal) of 0.8 M sodium nitrite and 380 L (100 gal) of 0.28 M sodium hydroxide. After sampling to assure tank farm corrosion, HWVP specifications and all applicable sampling/monitoring requirements are met (as defined in the Operating Specifications Document), the total batch of 13,900 L (3,670 gal) is then sent to an aging waste tank via AR Vault, followed by a water flush of 10,100 L (2,660 gal).

### 3.11 GLASS, GROUT, AND CESIUM STREAMS

Table 3-2 shows the expected composition of the streams going to the HWVP feed tank and the grout feed tank, and of the cesium solution stored in B Plant.

### 3.12 TIME CYCLES FOR UNIT OPERATIONS

The time cycle calculations initially developed in Reference 9 for the settle/decant operation are included in the process simulations in Reference 1. The settle/decant process will be the rate limiting step in the NCAW pretreatment process as shown in Figure 3-3, which illustrates the integrated time cycles for the various portions of the process. Figures 3-4 and 3-5 illustrate the time cycle for the settling/decant operations alone. At a 20 vol% settled solids level (higher than the 4 vol% expected in the demonstration, but more representative of the expected level of solids during production processing), and using a settling rate of 5 cm/hr (2 in/hr) in the primary settling tank, the process rate is 2.2E6 L/yr (590,000 gal/yr) or 1460 MTU/year. The effect on the plant process rate from varying the assumed settling rate parameter is shown in Figure 3-6.

Table 3-2. Composition of TRU Solids (Glass) and Low Level Waste (Grout) Streams

Component	Glass Stream <u>M</u>	Grout Stream <u>M</u>	Stored Cesium <u>M</u>
OH	3.8E-02	1.5E+00	
F	1.9E-03	7.4E-02	
NO2	3.8E-02	3.7E-01	
NO3	4.0E-02	1.7E+00	1.3E+01
SO4	3.3E-03	1.3E-01	
CO3	5.0E-03	2.0E-01	
Na	1.5E-01	5.0E+00	4.7E+00
Al	1.9E-01	3.9E-01	6.4E-01
Cr	5.2E-03	9.2E-03	
Fe	2.5E-01	4.9E-05	
Sr	1.5E-03	3.1E-07	
Zr	1.6E-01	3.2E-05	
Cs	9.5E-06	2.2E-05	3.7E-01
K	2.6E-03	1.0E-01	2.7E-01
Rb	2.4E-06	5.6E-06	9.3E-02
U	1.4E-02	2.9E-06	
PO4	5.4E-04	2.1E-02	
Ca	5.8E-02	1.7E-04	
Pb	1.1E-03	3.1E-04	
Mg	2.5E-02	3.6E-05	
Mo	9.9E-04	7.3E-04	
P	2.4E-02	1.4E-02	
Si	2.2E-01	4.4E-05	
Ba	3.1E-03	6.2E-07	
B	2.5E-02	5.0E-06	
Cd	2.2E-02	4.4E-06	
Ce	5.1E-03	1.0E-06	
Co	2.6E-04	5.1E-08	
Cu	1.4E-03	2.7E-07	
Mn	6.9E-03	1.4E-06	
Pd	4.0E-02	8.1E-06	
Ag	4.8E-04	9.5E-08	
Ti	7.3E-04	1.5E-07	
Zn	1.8E-03	3.5E-07	
Ni	3.0E-02	6.0E-06	
Nd	4.8E-03	9.5E-07	
La	3.1E-03	6.2E-07	

Table 3-2. Composition of TRU Solids (Glass) and  
Low Level Waste (Grout) Streams

(Components below in g/L)		
TOC	4.7E+00	3.9E-01
Pu	9.5E-03	1.9E-06
Am	9.4E-03	1.9E-06
Np	4.2E-02	8.4E-06
Diat. Earth	1.4E+00	8.3E-03

For radioactive components (Ci/L on 10/1/90)

Cs137	4.3E-02	1.0E-01
Sr90	8.5E+00	1.7E-03
Tc99	4.4E-02	8.8E-06
Ra226	5.5E-02	1.1E-05
Rh/Ru106	1.1E-01	1.8E-02
Ce/Pr144	6.4E-01	1.3E-04
Eu155	1.2E-01	2.4E-05
Sb125	1.4E-01	2.9E-05
BTU/hr/L	0.22	2.3E-03

Note: Unreported OH- assumed to account for  
overall charge balance.

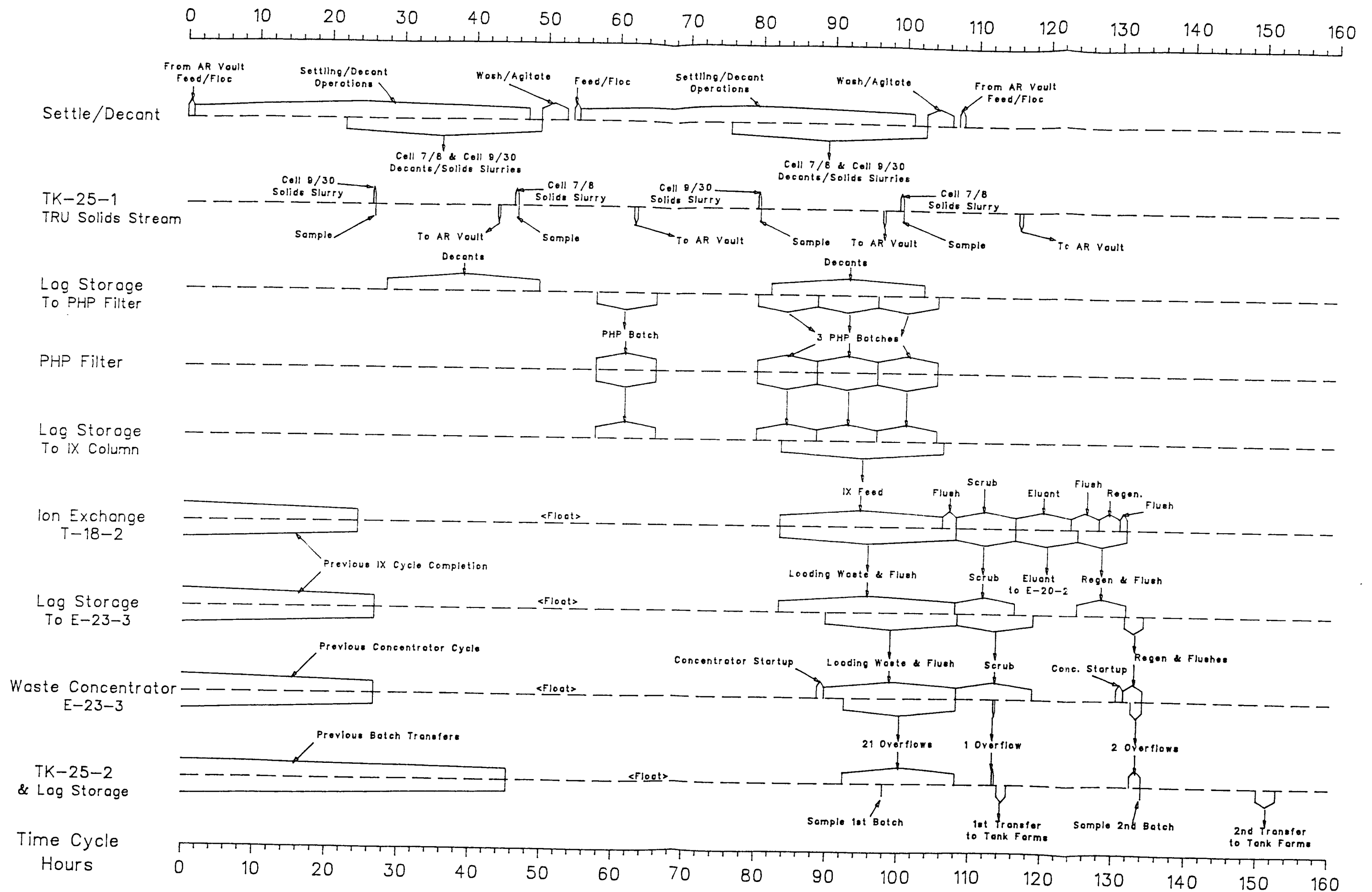


Figure 3-3. Integrated Time Cycle



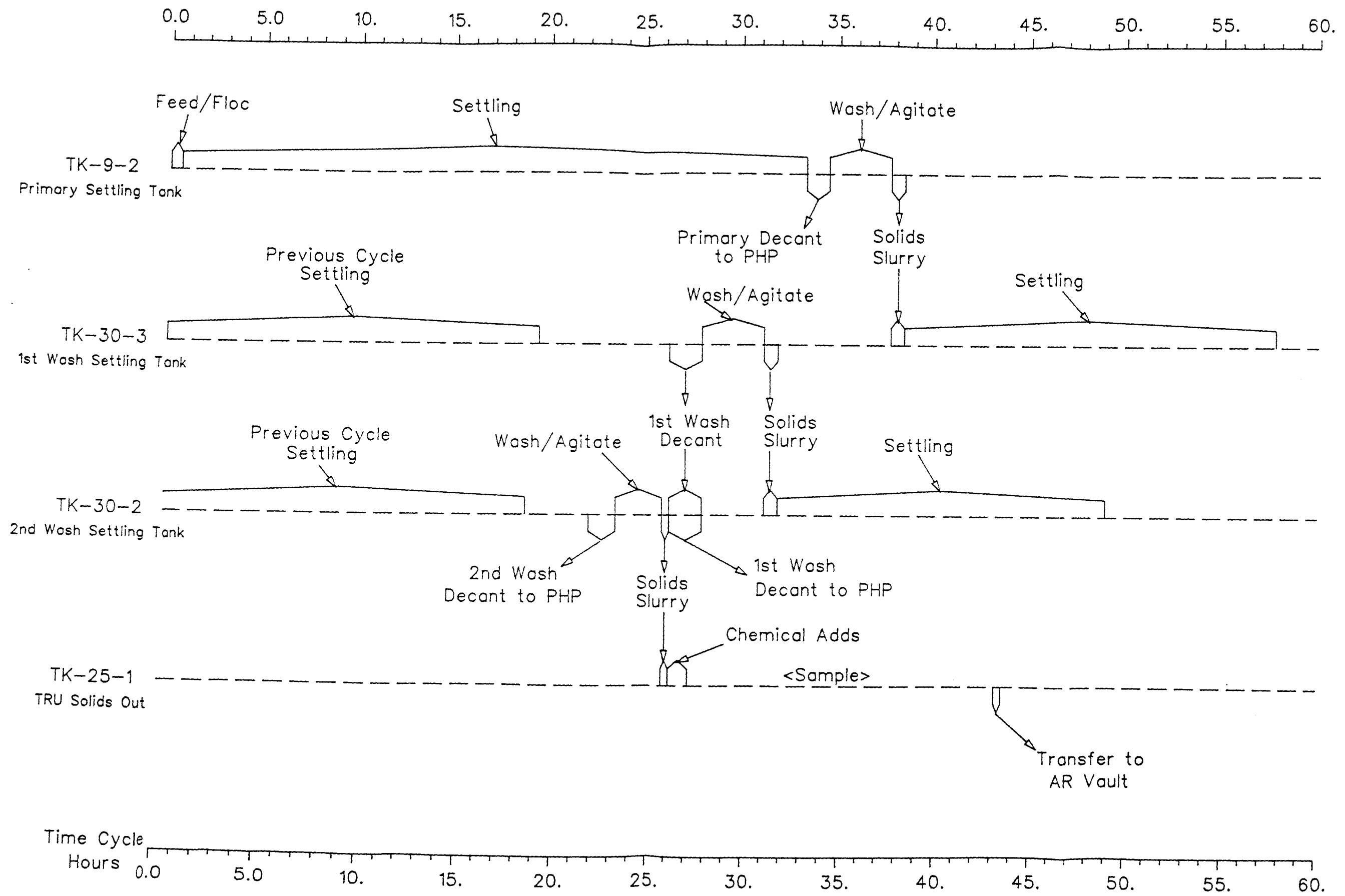


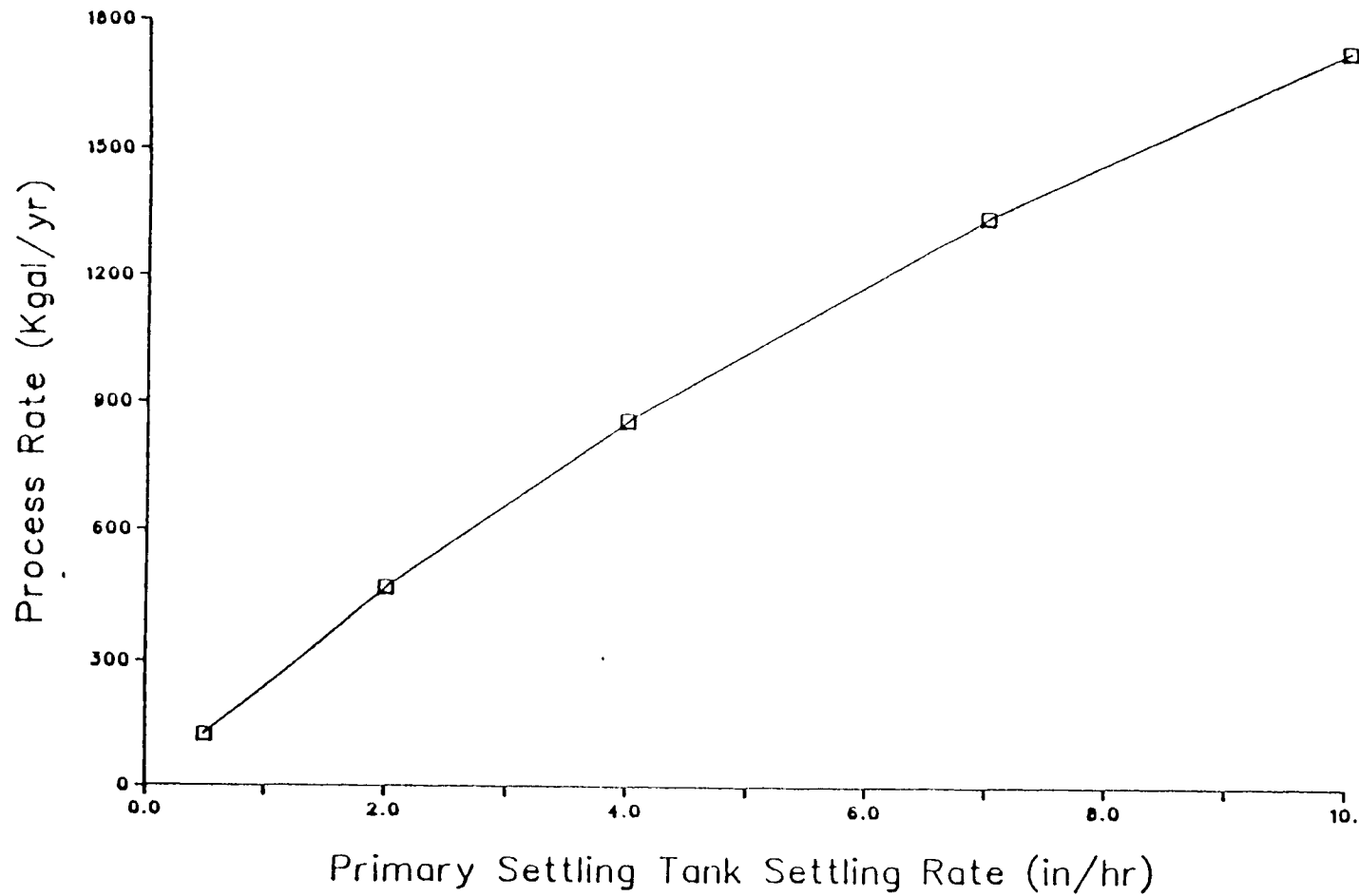
Figure 3-5. Cell 9/30 Time Cycle

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Figure 3-6 Settling Rate Versus Process Rate  
For 4.0 Vol% Settled Solids Feed



The 5 cm/hr (2.0 in/hr) settling rate is expected to be conservative for the 4.0 vol% settled solids feed during the demonstration but representative of the rates for processing an entire tank of NCAW.

The time cycle figures also illustrate the requirements for sample turnaround at several key points in the process. Sample turnaround must be approximately 16 hours for the TRU solids in TK-25-1 to allow transfer out of B Plant before another solids batch is available from the other settle/decant routing. Since settle/decant is the limiting time cycle in the overall process, any delays would affect plant rates.

Process rates for the PHP filter can be up to a 114 L/min (30 gpm) filtrate rate based on the plant process test (Reference 10). Based on the IX and cell 23 concentrator time cycles, a PHP filtrate rate of 76 L/min (20 gpm) is required. This also takes into consideration the lag storage between all of the unit operations. This PHP rate will maintain a continuous feed to the IX column, which operates at a 114 L/min (30 gpm) feed rate. Due to the difference in feed rates, the PHP filter must process at least one batch into the lag storage before the IX feed is started (See Figure 3-2). A typical batch can be processed through the PHP time cycle in about 8 hours.

The time cycle for the ion exchange/concentration process is shown in Figure 3-7. This time cycle assumes that the concentrator must support a continuously fed loading waste batch from the IX column, and that lag storage after the concentrator will allow storage of the approximately 38,000 L (10,000 gal) of concentrated product from the loading waste and flush. A sample turnaround time of 23 hours will be required to allow transfer of the first tank of low level waste out of the plant to make room for further overflow batches from concentration of the elution flush and regeneration streams.

Sample turnaround for the concentrated waste is TK-25-2 has been a matter of concern. TK-25-2 operations have a potential to create a process limitation with regards to transfers from cell 25 to the tank farms. The waiting periods for sample results before transferring wastes to tank farm may create a bottleneck, and lag storage tanks TK-29-3 and TK-32-1 need to be used to prevent delays while waiting for analyses of TK-25-2. This is due to the fact that the concentrated wastes from an entire IX cycle, which must be performed continuously, cannot be accommodated in TK-25-2.

The time cycle must also allow for other miscellaneous waste concentrations and for the second IX cycle waste concentrations once every five first cycles. A target sample turnaround time of 16 hours has been established to meet the TK-25-2 sampling needs. The 16 hour target is based on the probable lab capabilities and the time required to obtain and transfer the sample to 200W Area from B Plant. The Delayed Neutron Activity Analysis System (DNAAS) now being developed may have the capability to supply the TRU characterization in the needed time frame. If sample results cannot be supplied in the needed time frame, process rates could be affected since the waste cannot be transferred from the plant until analysis shows that operating specifications have been met.

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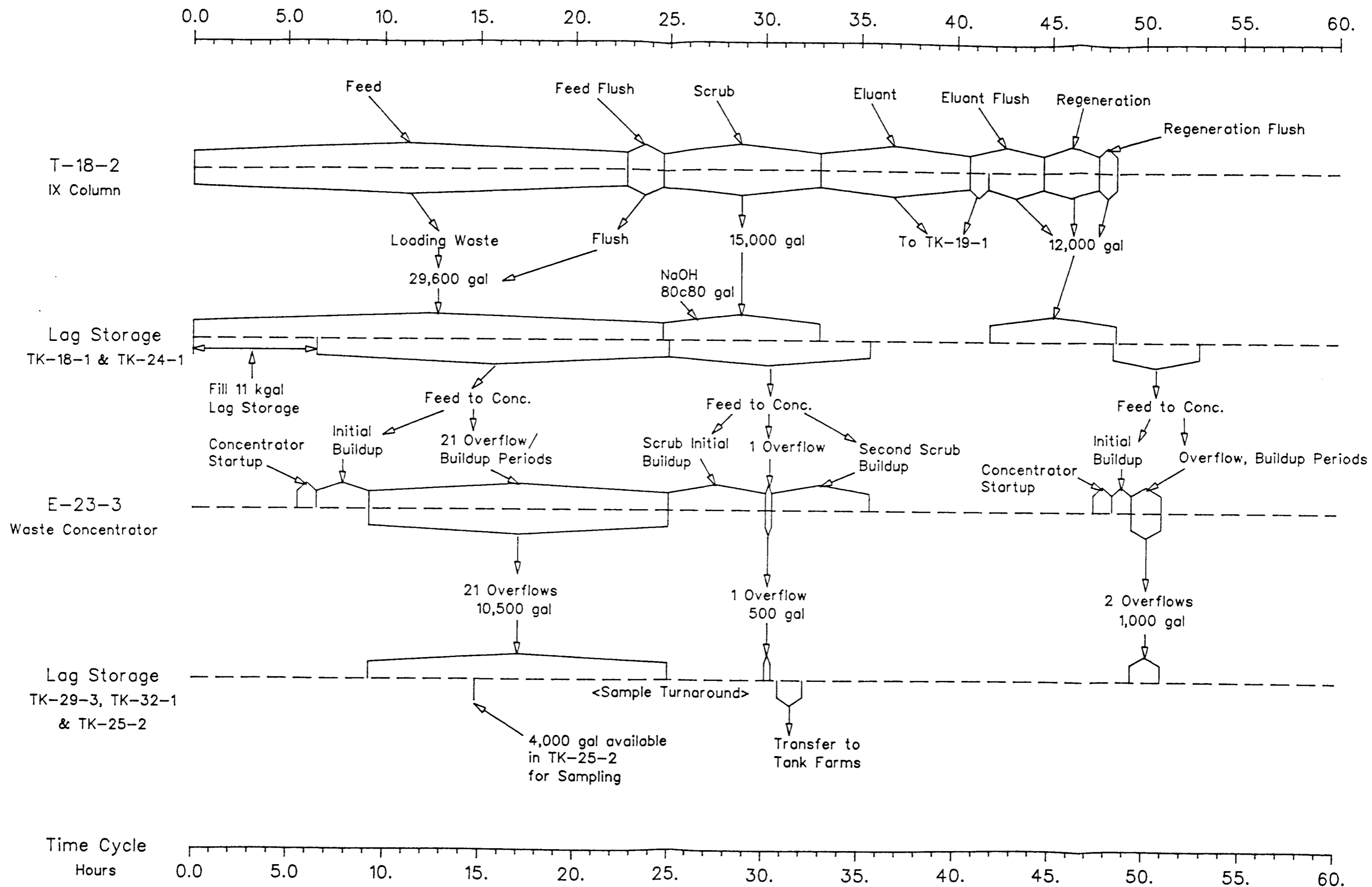


Figure 3-7. IX/Concentrator Time Cycle

The average concentrator process feed rate is approximately 160 L/min (42 gpm). The concentrator normally operates at 30 gpm except for overflow periods when it operates at 55 gpm. This rate should support the ion exchange and settle/decant process rates without being overall process rate limiting.

The direct transfer of the concentrated wastes to tank farms is also a possibility that could be investigated. This is based on sampling the NCAW supernate downstream of the PHP Filter. Another option would involve an on-line TRU monitor after the E-23-3 concentrator. These alternatives would allow immediate transfer of TK-25-2 contents to tank farms when it was filled, but would require process demonstration to provide the same level of assurance as direct analysis that operating specifications would be met.

#### 4.0 PROCESS TECHNOLOGY

The development of process technology for the pretreatment of NCAW at B Plant included early solid/liquid separation tests on centrifugation and inertial filtration which were not successful (References 11 and 12). Further development work on several alternative processes for primary liquid/solids separation and polishing filtration was performed and the settle/decant/PHP filter process described in this flowsheet was selected. Process operations which were not selected but were investigated included deep bed filtration (Reference 13) and high gradient magnetic filtration (References 14 and 15).

Centrifuge testing was included in the process test performed at B Plant (Reference 16), but the results were inconclusive. Since settle/decant tests in the laboratories and in B Plant were successful, further consideration of centrifuge operations has been dropped.

#### 4.1 FEED CHARACTERIZATION

The feed characterization samples from the NCAW received in B Plant for the process test had from 2 to 4 vol% settled solids compared to 20 vol% settled solids (9-10 vol% centrifuged) seen in the samples from TK-101-AZ (References 6 and 16). Synthetic NCAW solutions have had 20 to 30 vol% settled solids. The amount of solids in the NCAW retrieved for the process test was 2.5 weight percent or less, compared to the 3 to 4 weight percent seen in synthetic and TK-101-AZ NCAW samples. These results indicate that a representative amount of solids may not have been present in the NCAW retrieved for the process test.

Characterization sample results for the process test and for earlier samples from TK-101-AZ are compared in Table 4-1. This comparison tends to support the hypothesis that low solids were present in the solution transferred to B Plant for the process test, compared to the amount of solid components found in the earlier TK-101-AZ sample.

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Table 4-1. Characterization Sample Results

## B Plant Samples

	#1	#2	#3	#4	#5	TK-101-AZ
SV%	3.8	3.5	2	2	2	20
CV%	1.4	1.2	0.8	0.8	0.8	9.0
SpG	1.17	1.2	1.17	1.14	1.14	1.17
mol/L						
OH	1.0E+0	9.8E-1	4.2E-1	NA	NA	1.0E+0
PO4	1.4E-2	1.8E-2	1.1E-2	NA	NA	2.5E-3
SO4	1.5E-1	1.4E-1	1.2E-1	NA	NA	1.5E-1
NO3	1.6E+0	1.5E+0	1.2E+0	NA	NA	1.7E+0
NO2	5.8E-1	5.7E-1	4.1E-1	NA	NA	4.3E-1
CO3	1.9E-1	2.0E-1	1.6E-1	NA	NA	2.3E-1
TOC	4.9E-2	4.5E-2	3.1E-2	NA	NA	1.4E-1
Al	4.4E-1	3.8E-1	3.0E-1	2.7E-1	8.9E-02	5.0E-1 *
Cr	1.2E-2	1.1E-2	9.1E-3	8.6E-3	8.4E-03	1.2E-1
Fe	6.6E-3	4.1E-3	6.4E-3	5.1E-3	1.3E-02	6.7E-2
K	1.1E-1	9.6E-2	8.0E-2	7.1E-2	8.4E-02	1.2E-1
Na	4.4E+0	4.2E+0	3.6E+0	3.3E+0	2.5E+00	5.0E+0 *
Ni	7.4E-4	4.6E-4	5.8E-4	5.6E-4	8.3E-04	8.2E-3
Si	4.7E-2	2.9E-2	2.4E-2	6.1E-3	1.2E+00	6.0E-2 *
Zr	NA	NA	3.3E-3	3.0E-3	3.9E-03	4.4E-2
Ci/L						
<sup>137</sup> Cs	2.0E+0	3.8E+0	1.5E+0	1.5E+0	6.5E+00	2.2E+0
<sup>90</sup> Sr	2.1E-1	2.1E-1	1.5E+0	NA	9.0E-01	9.1E-1
<sup>239/240</sup> Pu	4.7E-5	2.7E-5	4.0E-5	4.5E-5	4.6E-05	7.3E-4
<sup>241</sup> Am	1.5E-3	5.4E-4	1.0E-3	NA	9.8E-04	3.3E-2
g/L						
U	6.0E-2	3.5E-2	4.9E-2	7.5E-2	7.5E-02	9.4E-1

\* Parr dissolution technique known to have interferences.

SV% is settled solids volume percent.

CV% is centrifuged volume percent.

B Plant sample results from Reference 16.

TK-101-AZ sample results from References 6 and 7.

The demonstration flowsheet is based on the 4 vol% settled solids content seen in the process test samples. Since the process test solids levels appear low, the amounts of those components associated with solids may be low. Therefore, the amounts of the solid components given in Reference 6 and 7 for NCAW in TK-101-AZ were reduced by a factor of 0.71 (2.5 wt% / 3.5 wt%) for the material balance in the demonstration flowsheet. The material balance calculations for this case are presented in Reference 1.

It should be noted that most of the technology development was done using a synthetic NCAW with 20 vol% settled solids, and that during production processing higher solids levels are expected. A material balance flowsheet for 20 vol% settled solids NCAW, with no adjustment to the solid component amounts is given for information in Reference 1.

#### 4.2 PRIMARY SOLID/LIQUID SEPARATION - SETTLE/DECANT PROCESS

During the early testing of synthetic NCAW for centrifugation and inertial filtration, it was noted that small samples of the feed showed effective settling of solids and a relatively clear supernate. A small characterization sample of actual NCAW from TK-101-AZ also exhibited good solids/liquid separation in a settling test in a hot cell. These observations and the failure of the centrifuge/inertial filter tests to achieve good separations efficiency prompted further investigations into a settle/decant process.

The Savannah River Plant (SRP) process for in-tank sludge settling was also reviewed during the early stages of the tests on NCAW settling (Reference 17). The results of lab and process tests at SRP indicated settling rates of 0.5 to 2.5 in/hr were occurring in their neutralized first cycle wastes. Since their waste is similar in density and in most major constituents to the Hanford NCAW, these data indicated that settling was a promising process for application to NCAW pretreatment at B Plant.

##### 4.2.1 Pilot Plant Settle/Decant Tests

A series of preliminary settling tests were run in the pilot plant in small graduated cylinders to ascertain whether the settle/decant process warranted further development (Reference 18). The tests included synthetic NCAW with solids loading of 20 vol% settled solids, similar to the expected feed during production processing, diluted solutions that represented washed solids, and tests using anionic polyelectrolytes. The polyelectrolytes are long chained organic molecules commonly used in industry to help agglomerate fine particles and increase settling rates. These tests showed that the synthetic NCAW did settle effectively in reasonable time periods, ranging from 3 to 9 hours. The washed solids appeared to settle slightly faster than the undiluted feed, as would be expected since the supernate viscosity in the washed solids is less. Two polyelectrolytes were tested, Betz #1143 and 1172. The Betz #1143 showed a slight improvement in the washed solution settling time, while no improvement was seen from the Betz #1172 polyelectrolyte.

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A matrix of larger scale settling tests was then performed in the pilot plant to allow comparison of the effects of column geometry, solution height, feed dilution and temperature on the settling behavior of synthetic NCAW. The main objective of these tests was to determine the settling rate at solution heights similar to those expected in the plant, 6 to 10 feet high, since the previous scoping tests were for solution heights of 18 inches or less. Again, the synthetic NCAW used for those tests contained approximately 20 vol% settled solids (undiluted). The tests that were run and a summary of the results are shown in Table 4-2 (Reference 19).

The typical settling behavior for a slurry is shown in Figure 4-1. The initial settling rate, called the hindered settling rate, is linear until a transition is reached. After the transition, a further decrease in the settled solids volume is seen at a slower compaction rate. The mechanisms for the separation of the solid particles from the supernate are different for the two settling zones. In the hindered settling region, the particles settle through the supernate, hindered by interactions with each other and also limited by particle size and fluid viscosity. In the compaction settling region, the particles no longer are settling through the supernate, instead the supernate is being channelled or squeezed out of the settled solids layer.

The tests showed that for the synthetic NCAW, the hindered settling rate could be expected to be between about 1.3 and 4.6 cm/hr (0.5 and 1.8 in/hr). Faster rates were seen for washed slurries, up to 15 cm/hr (5.9 in/hr) for the 3:1 wash and up to 63 cm/hr (25 in/hr) for a 15:1 wash. Most of the data obtained for undiluted feed followed the pattern of Figure 4-1, with both a hindered settling rate and a compaction rate identified.

In tests with the washed solutions and low solids loading, clear interface between the supernate and the settled solids was not seen, as the solution appeared murky and gradually cleared to establish an effective settling rate or time period. The transition between the hindered settling rate and the compaction zone occurred when a level of 25-35 vol% settled solids was reached in most cases. The concentration of solids in the supernates was generally below 100 ppm, which is well below the maximum concentration that can be fed to a pneumatic hydropulse filter.

The effect of the polyelectrolytes on settling rates observed was minor, but several other flocculating agents did exhibit a significant effect on settling rates of the primary feed. Data for these tests in graduated cylinders are shown in Table 4-3 and Figure 4-2 (Reference 20).

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Table 4-2. Pilot Plant Settling Tests and Results  
Sorted by Hindered Settling Rate (HSR)

Test #	Diameter (in)	Height (in)	Feed Type	Temp (C)	HSR (cm/hr)	HSR (in/hr)
31	3	18	Washed 15:1	Amb.	66.0	26.0
36	3	72	Washed 15:1	Amb.	64.0	25.2
35	12	72	Washed 15:1	Amb.	27.2	10.7
37	1	6	Washed 15:1	Amb.	25.4	10.0
48	12	24	Washed 3:1	Amb.	16.5	6.5
49	12	24	Washed 3:1	Amb.	16.5	6.5
45	3	72	Washed 3:1	Amb.	15.0	5.9
44	3	72	Washed 3:1	Amb.	14.2	5.6
46	3	72	Washed 3:1	Amb.	11.7	4.6
30	3	6	Washed 15:1	Amb.	8.9	3.5
47	12	24	Washed 3:1	Amb.	8.1	3.2
38	12	84	Washed 15:1	Amb.	6.6	2.6
34	12	72	Dilute 10:3	Amb.	6.6	2.6
32	12	24	Dilute 10:3	Amb.	5.4	2.1
51	12	84	Undiluted	Amb.	4.6	1.8
56	3	72	Undiluted	Amb.	4.3	1.7
29	3	3	Washed 15:1	Amb.	4.3	1.7
52	12	72	Undiluted	Amb.	3.3	1.3
40	3	70	Dilute 10:3	Amb.	3.0	1.2
39	3	18	Dilute 10:3	Amb.	3.0	1.2
16	3	18	Diluted	Amb.	3.0	1.2
13	3	72	Diluted	Amb.	3.0	1.2
60	1	6	Undiluted	Amb.	2.8	1.1
33	12	12	Dilute 10:3	Amb.	2.8	1.1
25	12	72	Undiluted	45	2.7	1.1
11	12	72	Diluted	Amb.	2.6	1.0
55	3	72	Undiluted	Amb.	2.3	0.9
4	3	72	Undiluted	Amb.	2.3	0.9
53	12	19	Undiluted	Amb.	2.3	0.9
24	12	72	Undiluted	Amb.	2.3	0.9
20	3	71	Diluted	Amb.	2.2	0.9
43	1	6	Dilute 10:3	Amb.	2.1	0.8
2	3	18	Undiluted	Amb.	2.0	0.8
14	1	6	Diluted	Amb.	2.0	0.8
12	12	24	Diluted	Amb.	2.0	0.8
58	3	3	Undiluted	Amb.	2.0	0.8
15	1	2	Diluted	Amb.	1.9	0.8
19	12	24	Undiluted	Amb.	1.9	0.7
57	3	3	Undiluted	Amb.	1.8	0.7
6	3	6	Undiluted	Amb.	1.6	0.6
7	12	12	Undiluted	Amb.	1.5	0.6
1	1	6	Undiluted	Amb.	1.5	0.6
42	1	2	Dilute 10:3	Amb.	1.5	0.6
50	12	84	Undiluted	Amb.	1.3	0.5

Table 4-2. Pilot Plant Settling Tests and Results (Continued)  
Sorted by Hindered Settling Rate (HSR)

Test #	Diameter (in)	Height (in)	Feed Type	Temp (C)	HSR (cm/hr)	HSR (in/hr)
41	3	70	Dilute 10:3	45	1.3	0.5
3	12	18.5	Undiluted	Amb.	1.3	0.5
9	3	18	Undiluted	Amb.	1.3	0.5
18	3	18	Undiluted	Amb.	1.2	0.5
23	3	70	Undiluted	45	1.1	0.4
22	3	70	Undiluted	45	1.1	0.4
8	1	2	Undiluted	Amb.	1.0	0.4
61	1	2	Undiluted	Amb.	1.0	0.4
10	1	6	Undiluted	Amb.	0.8	0.3
54	3	84	Washed 3:1	Amb.	0.7	0.3
62	1	1	Undiluted	Amb.	0.6	0.2
27	3	6	Dilute 10:3	Amb.	0.5	0.2
5	1	1	Undiluted	Amb.	0.4	0.2
28	3	3	Diluted 10:3	Amb.	0.3	0.1
17	1	6	Undiluted	Amb.	0.3	0.1
59	1	6	Undiluted	Amb.	0.3	0.1
21	3	71	Diluted	45	0.1	0.0
26	12	72	Undiluted	45	0.0	0.0

Figure 4-1. Typical Settling Behavior

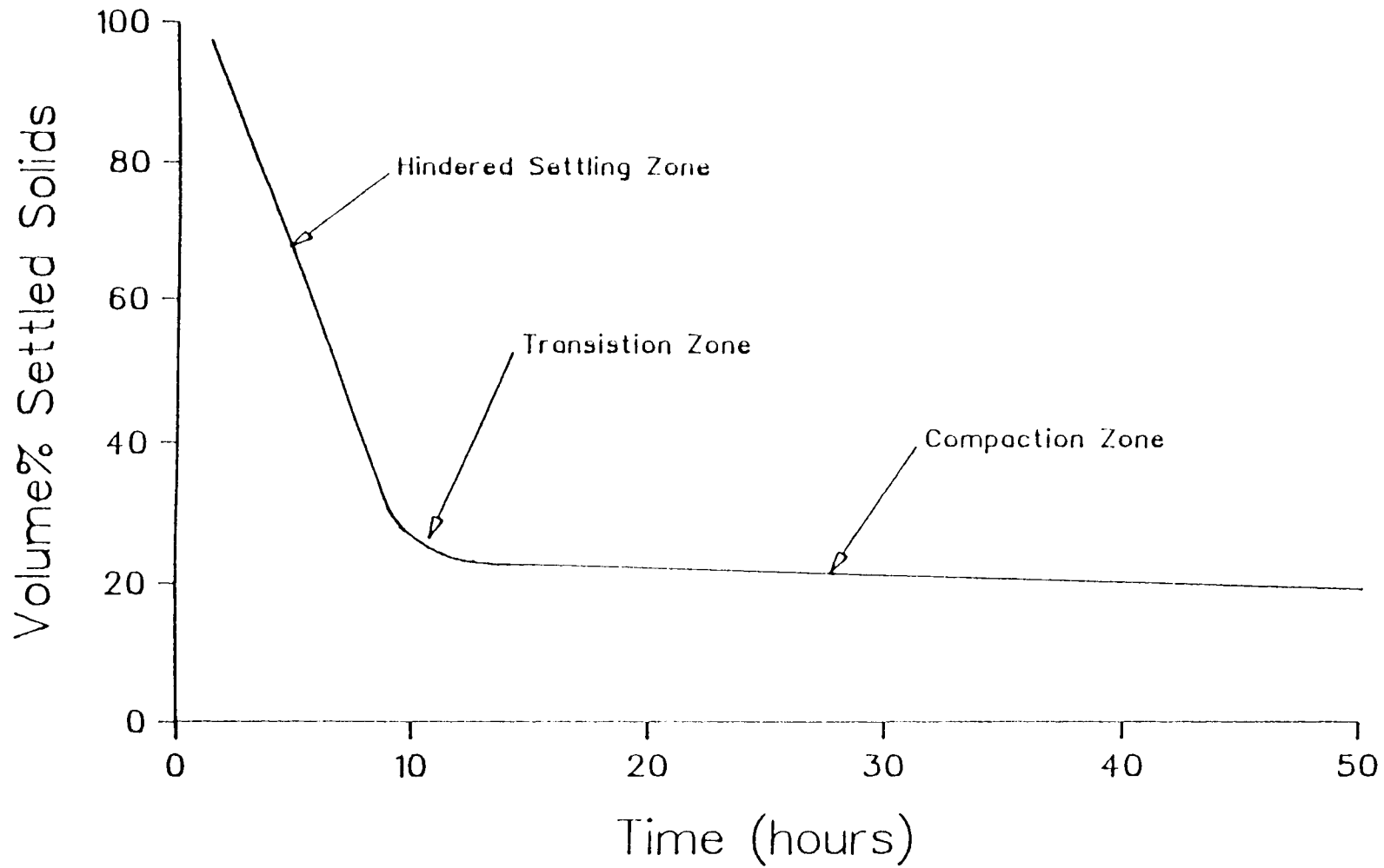
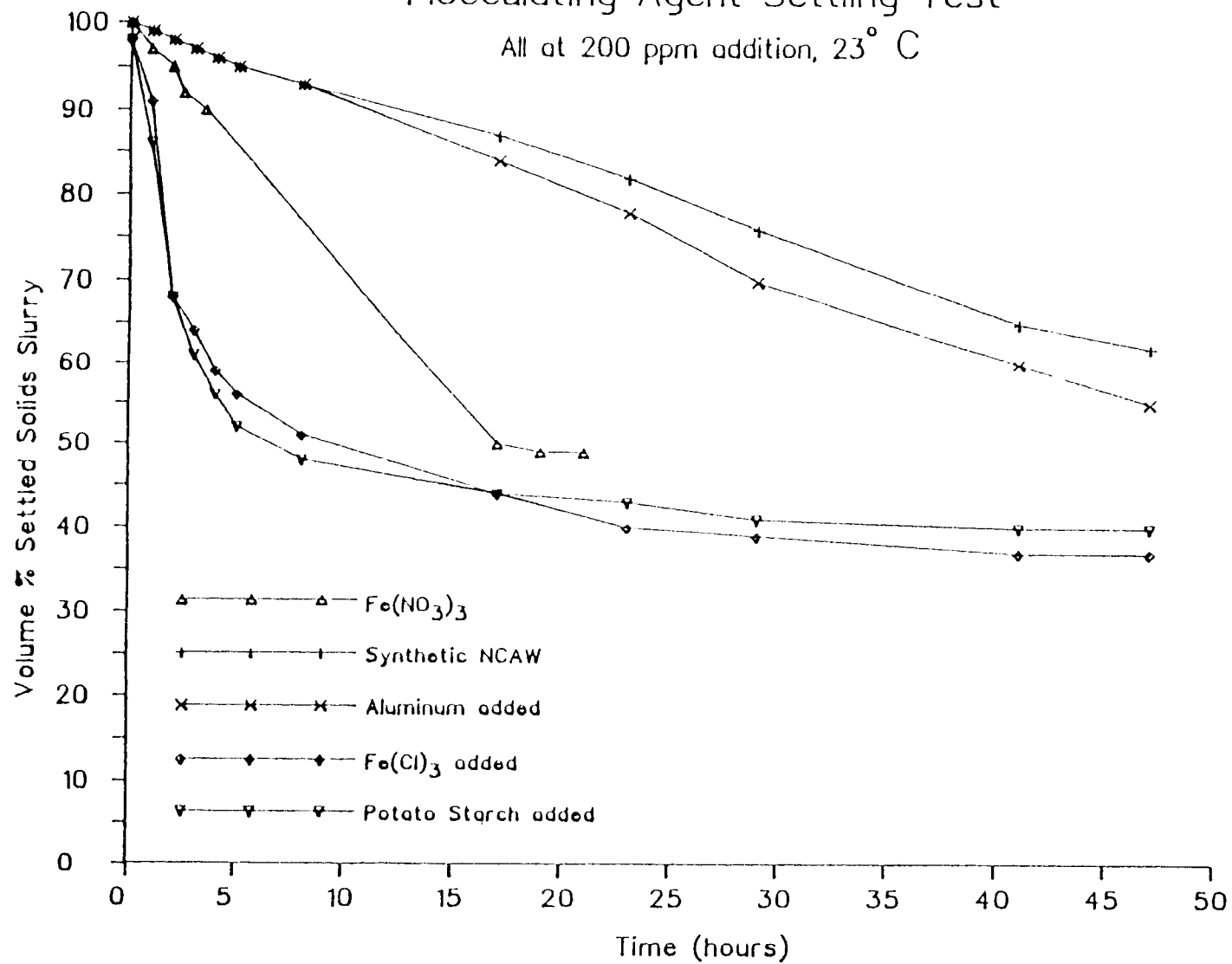


Table 4-3. Flocculating Agent Effects on Settling Rates

Flocculating Agent	Settling Rate - well mixed in NCAW		
	cm/hr	(in/hr)	
Ferric Chloride	6.4-7.6 6.6-7.9	2.5-3.0 2.6-3.1	at ambient temperature at 40 °C
Potato Starch	6.4-7.6 6.6-7.9	2.5-3.0 2.6-3.1	at ambient temperature at 40 °C
Alum	0.46	0.18	at ambient temperature
Sodium Chloride	3.3	1.3	at ambient, not mixed
Ferrous Sulfate	4.8	1.9	at ambient temperature
Ferric Nitrate	5.1-6.4	2.0-2.5	at ambient temperature
Synthetic NCAW (without additives)	1.0-4.6	0.4-1.8	at ambient temperature
Betz #1143 & 1172	Within synthetic NCAW range		

Figure 4-2. Flocculating Agent Settling Test

All at 200 ppm addition, 23° C



Ferric chloride and potato starch both appeared to enhance settling rates significantly. However, flocculating agents that included chlorine as a constituent were felt to be potential contributors to corrosion problems, and the potato starch exhibited tendencies to form globules and lose effectiveness without careful mixing and agitation that could be difficult to verify in the plant environment. Therefore, a ferric nitrate flocculating agent was selected for the process.

The effect of the additional iron from the ferric nitrate flocculate addition (added at a 200 ppm concentration to the primary feed) on the amount of waste oxides and thus glass produced is less than a 0.5 weight % increase.

Several final tests were run in the pilot plant at lower solids loading corresponding to the levels seen in the B Plant NCAW characterization samples. The settling rates observed, 13 to 40 cm/hr (5 to 15 in/hr) for the first settling cycle, were significantly faster than those observed for the undiluted 20 vol% settled solids solutions. The more conservative assumption of 5.0 cm/hr (2.0 in/hr) settling rate was used in the flowsheet due to the low number of tests run at the low solids level and to assure that the process throughput was adequate in a worst case situation. The effect of a faster settling rate was illustrated in Figure 3-6.

#### 4.2.2 B Plant Process Test - Settle/Decant Tests

A process test was performed in B Plant to verify and further test the settle/decant and PHP technology developed in the laboratories (Reference 10-16). Actual NCAW from TK-101-AZ was transferred to B Plant in an 11,000 gal batch for use in the process test. The composition of this solution is shown in Table 4-1. The analyses show that solids levels are lower than those expected in the overall NCAW solution stored in TK-101-AZ. The concentrations of soluble components in the feed received in B Plant matched well with TK-101-AZ analyses, after adjustment for transfer dilutions.

Seven settling tests were performed during the process test. Results of these tests are given in Table 4-4. The decantate from these tests were used in subsequent PHP filter tests without indications of problems with excessive solids in the PHP feed. Therefore the solids separation from settle/decant appears to be adequate to provide a feed to the PHP process. The volume of solids in the decantate was difficult to measure accurately at the small quantities present, but a pattern of increased solids removal for longer settling times was seen in this limited number of tests.

Table 4-4. B Plant Process Test Settling/Decant Results  
Settle/Decant Test Separation Efficiencies  
(from Reference 16)

Test	Settling Time	Efficiency Based On:		Ce/Pr	Solids
		Am	Pu		
1	24 hours	5.0%	>94.0%	94.2%	76.8%
2	48 hours	97.8%	>97.3%	>99.6%	87.2%
3	48 hours	98.9%	>92.2%	>99.8%	81.9%
4	72 hours	99.6%	>99.0%	>98.8%	94.0%
5	48 hours	97.8%	>98.1%	>99.4%	99.7%
6	72 hours	97.3%	>92.0%	> 5.2%	NA
7	48 hours	41.5%	>51.1%	NA	NA

Note the relative errors (discussed in the Reference) suggest the results for the solids level in the decantate may have a significant error associated with them (+/- up to 70%).

NA = not available

The TRU elements (plutonium and americium) may be associated with larger particles that settle faster since their removal efficiencies are above 92% for all the tests. A TRU concentration of 44 nCi/g (at the 99% confidence level) in PHP feed was predicted in the process test report based on the plutonium and americium separation efficiencies. These tests also alleviated concerns that convective mixing could significantly affect the settling process.

Washing efficiencies were examined by a single test with a wash dilution of approximately 2.5:1. Most components considered soluble behaved as predicted, with the dilution decreasing their concentrations by the expected amounts. An exception was the Total Organic Carbon (TOC), which had previously been considered fairly soluble, with an expected washing efficiency of 80%. However, this B Plant Test showed that the TOC behaved more as a component associated with the solids.

Based on the B Plant Test for washing efficiencies, and on the TK-101-AZ sample obtained in late 1985, a simple dilution model was selected to predict the behavior of soluble components. The first flowsheet revision used sludge washing efficiencies derived from 1984 lab tests. These tests were performed with synthetic NCAW which was different from the currently understood composition of NCAW. The sludge washing efficiencies for the most soluble components were all in the high 90's, so there appeared to be little real difference among them. Based on these considerations, a simple dilution model using the actual soluble fractions of components from the TK-101-AZ characterization was selected.

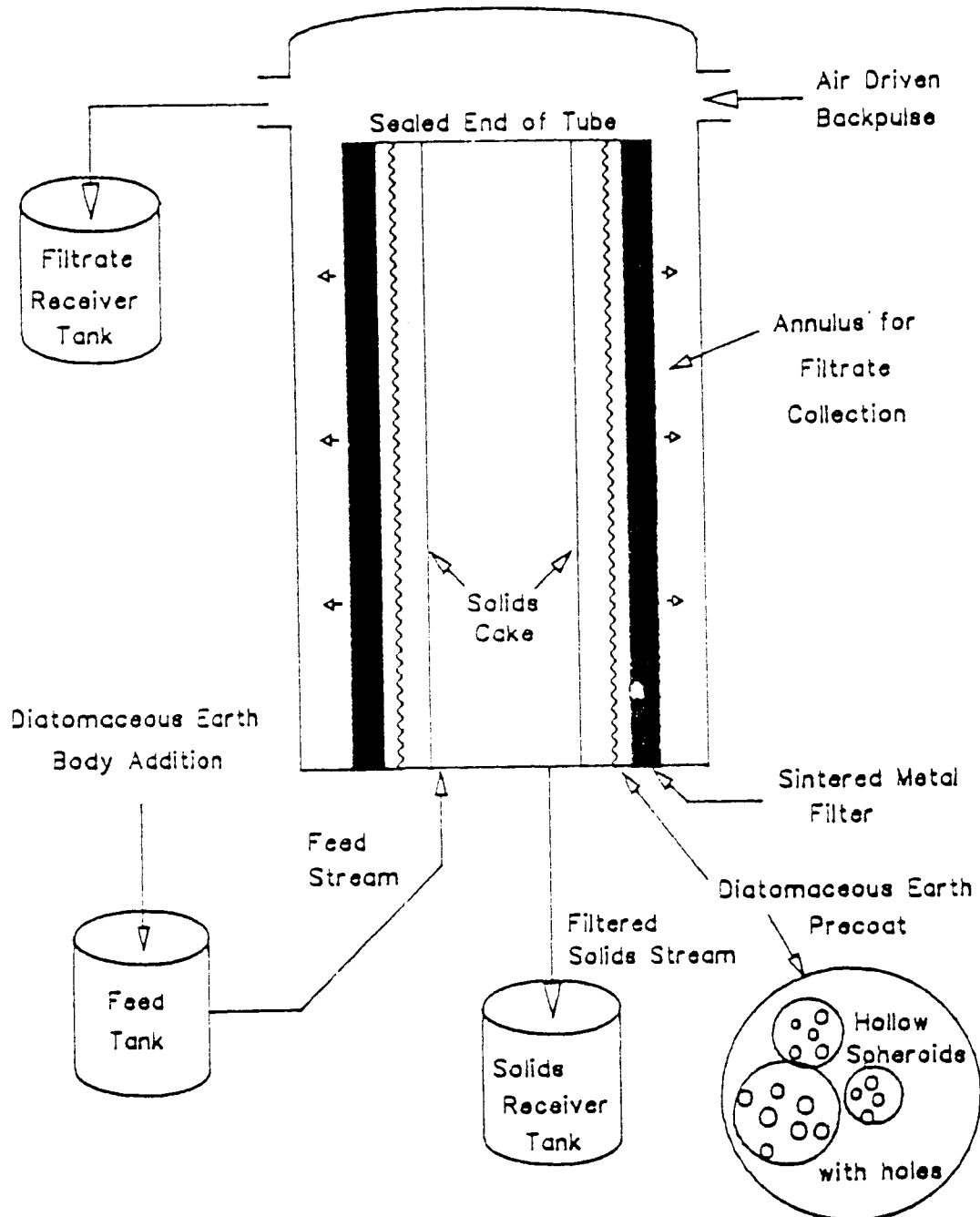
#### 4.3 POLISHING FILTRATION - PNEUMATIC HYDROPULSE FILTER

The need for a polishing filtration step has been established based on calculations that show the supernate must be below approximately 50 ppm solids to assure that the grout produced from it will be a low-level waste (below 100 nCi/g). Since the clarity of the supernate from the settle/decant process is conservatively assumed to be 100-300 ppm, the polishing filtration step is needed.

The key component of the pneumatic hydropulse (PHP) filter is a sintered metal filter element. Removal of solid particles down to submicron diameters can be attained with this type of filter. Figure 4-3 illustrates the operation of the pilot plant PHP filter in an inverted mode, with the feed solution introduced into the center of the filter element. After a solids cake is formed an air pressure backpulse dislodges the solids cake and flushes it down to a collection tank. The B Plant PHP filter will operate in a similar fashion, but is composed of a tube bundle of 37 sintered metal filter elements, each 1-1/2" outer diameter.

A filter aid, diatomaceous earth (DE), is generally used in the operation of the PHP filter. The DE is used as a precoat on the filter surface to prevent excessive penetration of the filter pores by the feed solids,

Figure 4-3. Typical Pilot Plant  
Inverted Pneumatic Hydropulse  
Filter Operation



which can lead to plugging and require more frequent backflushing or nitric acid cleaning cycles. The DE is also used as a body feed (combined with the feed at a specific ratio) to aid in formation of a solids cake that is not easily compressible and that allows continued filtering action as it builds up in thickness.

The main constituent of the DE is  $\text{SiO}_2$ , which is also the major component of the glass formulation for the Hanford Waste Vitrification Plant. The other components can be expected to cause a slight increase in the waste oxides to glass. The composition of a typical DE is given in Table 4-5. At the flowsheet levels of diatomaceous earth use, there will be a 0.16 wt% increase in the waste oxides per MTU going to glass. Figure 4-4 shows the effect of different levels of diatomaceous earth body feed additions on the waste oxides level. Estimates of the overall effect of the diatomaceous earth addition on glass costs showed that even at higher addition levels, and with conservative assumptions on loading cycles (about 17 minutes/cycle compared to the 480 minutes found in the flowsheet development work), the incremental cost (about \$7 million) was not significant compared to overall NCAW disposal costs (Reference 21).

#### 4.3.1 Initial Scoping Tests of the PHP Filter

Initial tests of the PHP filter were run to determine if it would be applicable for polishing filtration in the NCAW pretreatment process. The tests, using synthetic NCAW, showed that filtrate clarity could be expected to be very good (less than 4 ppm solids) with feed solids concentrations between 50 and 1000 ppm. A summary of the results given in Reference 22 is shown in Table 4-6. Since the solids concentration in the decantates from the settle/decant process are expected to be between 100-300 ppm the two processes appeared to match.

These initial scoping tests were run using the full pump head to drive the filter, and the filter loading time was difficult to determine since the filtrate rate rapidly reached a maximum and then dropped off slowly. Subsequently, the vendor recommended that the PHP filter be operated with a throttle valve on the feed side to allow a controlled buildup of the feed pressure. This allows better solids cake formation without compression occurring and leads to longer times between backpulse cycles.

#### 4.3.2 Pilot Plant PHP Filter Tests

After the initial scoping tests showed that the high separations efficiency required in the process could be achieved by the PHP filter, a series of tests were run to further define the operating parameters. These tests were run with feed solids concentrations of 500 and 1,000 ppm, except for

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Table 4-5. Composition of Typical  
Diatomaceous Earth

<u>Component</u>	<u>Weight%</u>
SiO <sub>2</sub>	91.1
P <sub>2</sub> O <sub>5</sub>	0.2
TiO <sub>2</sub>	0.2
CaO	0.5
MgO	0.6
K <sub>2</sub> O	0.55
Na <sub>2</sub> O	0.55
Al <sub>2</sub> O <sub>3</sub>	4
Fe <sub>2</sub> O <sub>3</sub>	1.3
Misc.	0.5

Figure 4-4. Effect of Diatomaceous Earth Body Feed on Waste Oxides  
For 4.0 Vol% Settled Solids Feed

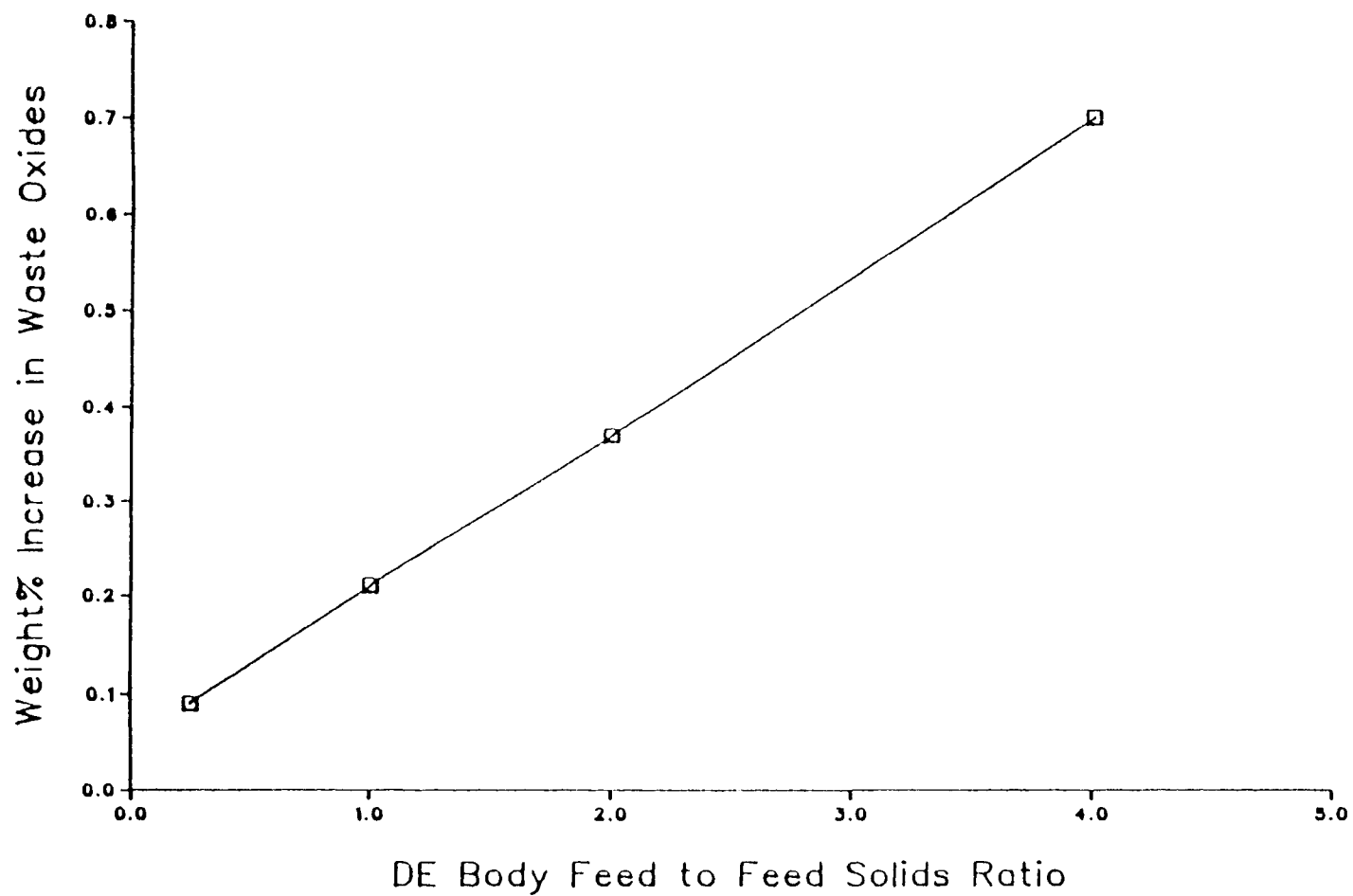


Table 4-6. Initial Scoping Test Results for the PHP Filter  
(Data from Reference 22)

Run Number	Feed Solids (ppm)	Filtrate Volume/ Filter Area (gal/ft <sup>2</sup> )	Run Time (minutes)
1	1000	2.51	3
2	50	15	14
3	200	16.7	14
4	500	5.61	10
5	500	7.52	18
6	740	4.08	13
7	740	3.18	13
8	200	15.7	17
9	50	15.5	10

one test with a solids concentration of 8,000 ppm to simulate a process upset. Table 4-7 shows the tests run and their results (Reference 23).

Filtrate clarity was very good, with the average concentration below 10 ppm for all tests that were run. The solids concentration in the filtrate was highest in each test when the feed was first fed to the filter, then dropped off as the solids cake built up, as shown in Figure 4-5. The maximum filtrate solids level seen was 35 ppm at the beginning of one run. The effect of average filtrate solids concentration on the TRU level in the grout is shown in Figure 4-6. At the expected 10 ppm solids concentration in the PHP filtrate, the estimated TRU level in grout is 4 nCi/g, well below the 100 nCi/g limit for low-level waste.

The amount of DE added was evaluated for its effect on tank farm volumes required for storage. No significant effect on volume or on chemical/physical properties of the NCAW solids stored in the tank farms is expected (Reference 24). Pilot plant tests of DE aged at 80 °C for two weeks with synthetic NCAW also showed that there was no tendency of the DE to affect resuspension properties of the NCAW solids (Reference 25).

#### 4.3.3 B Plant Process Test - PHP Filter Tests in WESF

Supernatant from the settle/decant tests in the B Plant canyon was transferred to the Waste Encapsulation and Storage Facility (WESF) hot cells, where pilot scale PHP tests were done. A number of tests were run to verify design and operation parameters for the full scale PHP filter, and to establish limits of operations for solids removal. The results are reported in Reference 10.

Tests were performed on both a low solids feed, with only a few hundred parts per million solids, and a higher solids feed that included raw NCAW solution in addition to the supernates from the settle/decant tests. The low solids feed tests were intended to represent normal process feeds, while the high solids tests were to check the effects of process upsets.

Results from the low solids feed processing showed that at twice the design flow rate (35 L/min/m<sup>2</sup>, or 0.4 gpm/ft<sup>2</sup>) through the filter, a batch size equivalent to 220,000 L (57,000 gal) could be processed. The backpulse operation to remove solids was accomplished successfully, and the filter restored to its original differential pressure.

Tests using high solids feed showed that differential pressures across the filter increased more rapidly, and batch sizes were slightly reduced. Feed rates of more than twice the design flux were tried, with results showing that some fouling of the filter element occurred. This fouling was successfully cleaned out with a four hour 1 M nitric acid soak.

Table 4-7. PHP Filter Test Results  
(Data from Reference 23)

Concentration of Solids in Feed (PPM)	Body Feed DE:Solids Ratio	Precoat (g)	Run Time (minutes)
1,000	0		25
500	0		69
1,000	0	20	55
500	0	20	80
7,580 *	1:1.2		82
1,000 **	1:2		660
1,000	1:3		97
1,000	1:3	20	120
1,000	1:4		45
1,000	1:4	20	58
1,000 **	1:2		235
1,000 **	1:2	20	267
1,000 *	1:1		324
1,000	1:3		199
1,000	1:2		70
1,000	1:2		128
1,000	1:2	20	930
3,000	1:1		285
1,000	1:2		50
1,000	1:4		136
1,000	1:4		137
1,000	1:4	20	51
1,000	1:4		24
1,000	1:3		84
1,000	1:3		37
1,000	1:4	80	515
1,000	1:4	40	539
1,000	0	40	79
1,000	0	80	87
1,000	0	160	82

\* Large solids in backflush solution, 2" diameter

\*\* Small solids in backflush solution, 0.75" diameter  
1.9 ft<sup>2</sup> pilot plant filter

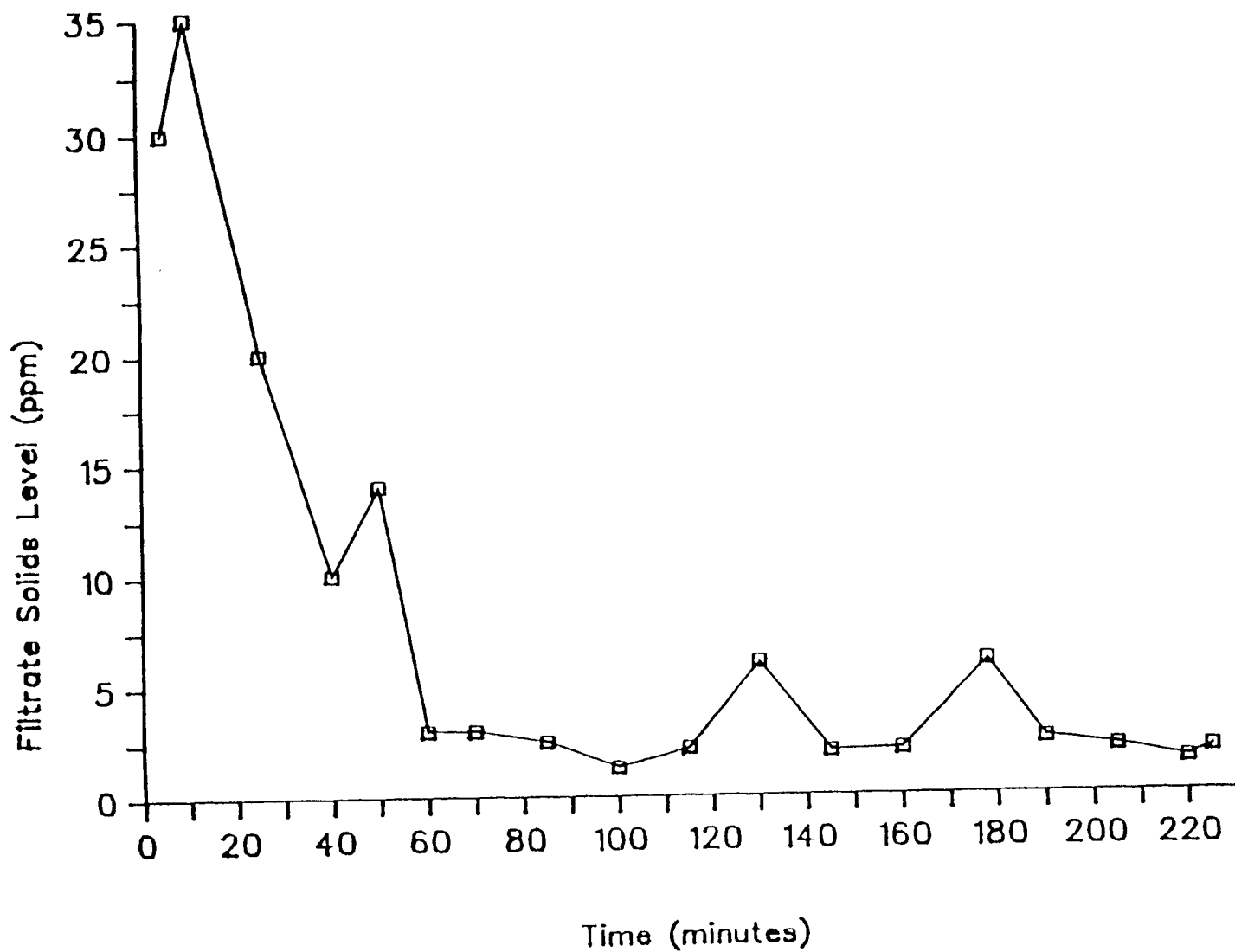
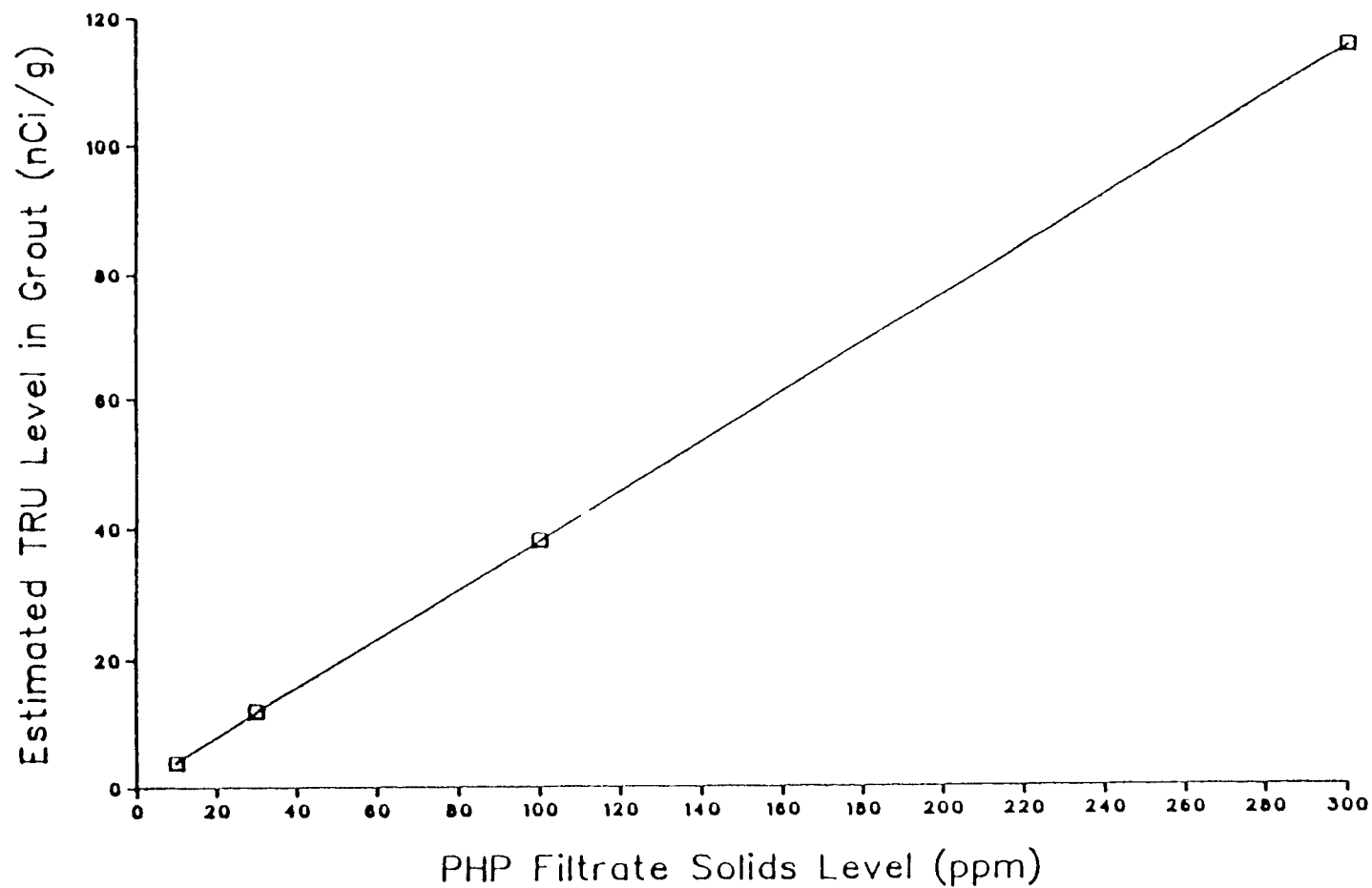


Figure 4-5. Solids Level in PHP Filtrate

Figure 4-6. TRU Level in Grout Vs. PHP Filtrate Solids Level  
For 4.0 Vol% Settled Solids Feed



The low and high solids feed tests used both precoat and body feed diatomaceous earth in similar amounts to those suggested in this flowsheet. A test was also completed to determine the effect of feeding NCAW supernate to the PHP filter without a precoat or body feed addition. This test showed that after one feed batch was processed, little effect on the filter operation was seen, but during a second batch of feed processing the filter plugged. Two soaking periods, for 1 week, then for 4 hours, with 1 M nitric acid resulted in a filter differential pressure of 4 PSI compared to the 2-3 PSI seen in an unfouled filter element.

Separation efficiencies for plutonium and americium were reported to be 96% and 98% respectively, closely approximating the assumed removal in the flowsheet. The overall solids removal (67%) was not as good as expected, but this was probably due to the analytical method which included filtering, air drying and weighing of very small solids amounts, which could lead to large inaccuracies. The filtrate from the PHP filter contained approximately 0.05 nCi/mL of TRU activity, which should easily meet the required TRU limits for grout.

#### 4.4 CESIUM REMOVAL BY ION EXCHANGE

Previous processes in B Plant have used ion exchange to separate cesium from basic streams. The resin most recently used, Duolite ARC-9359 (trademark), is no longer manufactured and a replacement resin had to be identified for NCAW processing. Another consideration in development of the ion exchange technology for NCAW processing was the use of ammonium carbonate as the eluant solution. The ammonia from the sodium scrub portion of this process was boiled off in the E-23-3 concentrator and disposed of with the B Plant process condensate (BCP) stream. Ammonia in the BCP stream reduces the life expectancy of disposal cribs by several years, resulting in increased capital costs over the life of a process. Ammonia is also regulated by CERCLA/RCRA with strict disposal limits now in force that were not a concern in the past.

Advantages of the nitric acid flowsheet compared to the previous ammonium carbonate flowsheet include (Reference 26):

- o No ammonia flammability concerns
- o Less labor for eluant makeup
- o No ammonia in BCP stream
  - Life cycle costs savings of \$10 million on Project B-647
  - Easier to remove Cs from BCP stream by IX since ammonium ion competes with Cs for IX sites
  - Extended crib life due to less migration of radionuclides since ammonium ion competes with Cs and other radionuclides for adsorption sites in soil

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- o Nitric recycle to minimize required eluant makeup
- o Avoid possible additional treatment costs to drive off the residual ammonia associated with ammonium carbonate flowsheet before sending the Cs eluant to HWVP
- o Ammonium carbonate make-up facility project will not be required
- o More efficient operation can be obtained for the E-20-2 and E-23-3 Concentrators due to reduced fouling

Disadvantages include:

- o Requires close control to keep concentrated nitric acid from contacting IX resin.
- o Nitric acid eluant flowsheet requires more sodium hydroxide (NaOH) neutralization than required for ammonium carbonate flowsheet resulting in more liquid waste to grout
- o Product cation (Na+K+Rb) to Cs mole ratio estimated too high for previous purification/encapsulation flowsheet even after 3 IX cycles

#### 4.4.1 Resin Selection Tests

After a literature search of the several IX resins available, batch contact tests were run on the six most promising, candidate resins for replacement of the previously used ARC 9359 resin. These tests consisted of placing the resin in synthetic NCAW supernate, allowing time for the resin to adsorb cesium from the solution, and analysis of the solution to determine the amount of cesium exchanged onto the resin. The results of the tests are shown in Figure 4-7 (Reference 27).

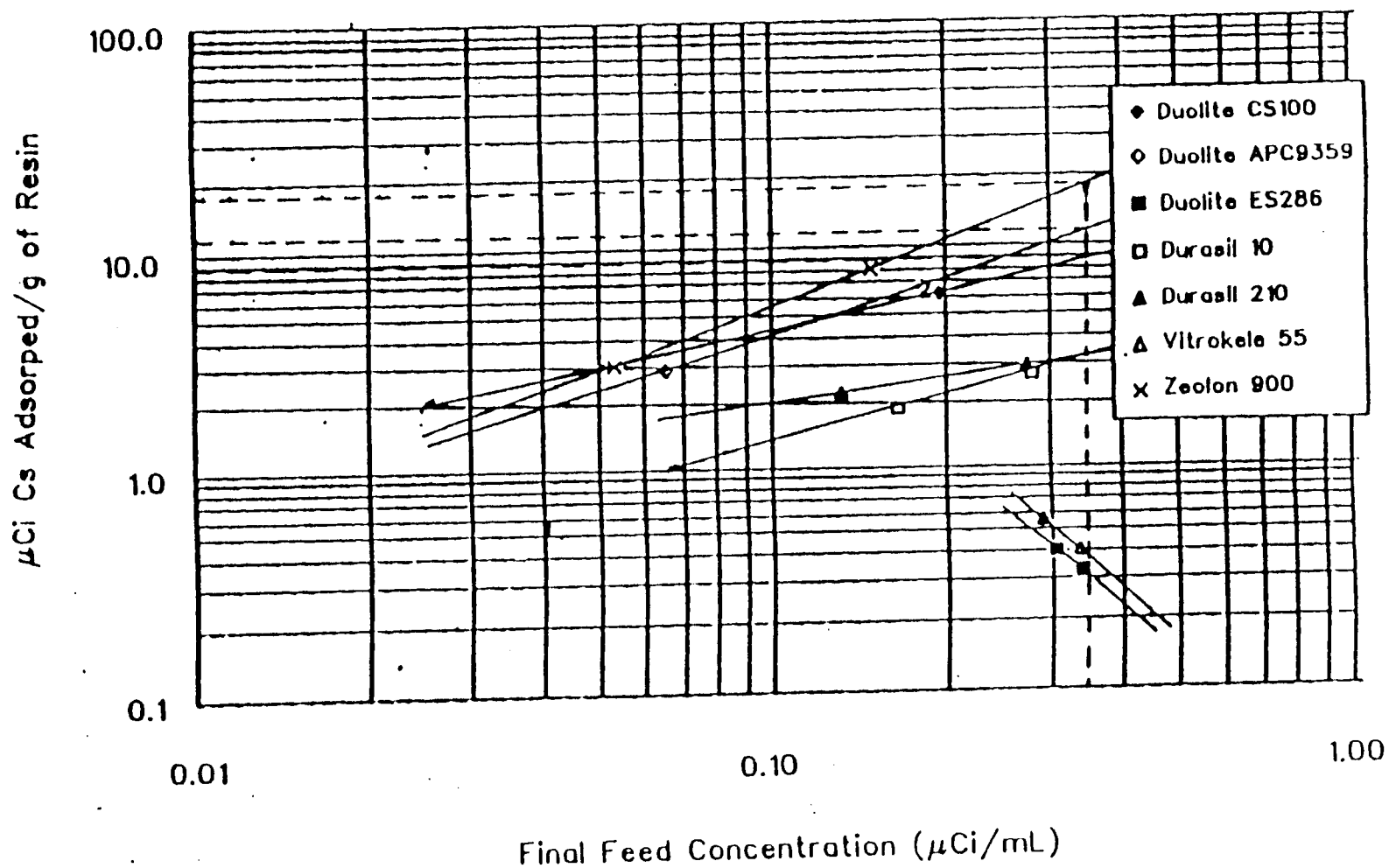
The best results for cesium loading were for Zeolon 900 (trademark) resin, with ARC 9359 (trademark) next, followed by Duolite CS 100. Since Zeolon 900 and ARC 9359 are no longer manufactured the Duolite CS 100 was selected for further process development tests. This resin is the vendor's recommended replacement for the discontinued ARC 9359 resin. A further advantage for the CS 100 resin is that it can be eluted with up to 1 M nitric acid according to the manufacturer, thus providing an alternative to the ammonium carbonate eluant.

#### 4.4.2 Column Loading Tests for Duolite CS 100

After selection of Duolite CS 100 resin, lab tests were run in an ion exchange column setup to establish parameters for both an ammonium carbonate and a nitric acid eluant flowsheet (Reference 27). The test plans included a number of column runs to establish the effect of flow rate through the column (important for scaleup considerations), amounts of feed and flush, and concentrations in the input stream. Table 4-8 shows the key tests that were run.

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Figure 4-7. Cesium Absorbance for Alternate Ion Exchange Resins



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Table 4-8. Test Conditions for HNO<sub>3</sub> Flowsheet

FIRST CYCLE						
Run	Flow Rate (cm <sup>3</sup> /hr)	Residence Time (min)	Feed	Na Scrub	Cs Elution	Comments
D	60	18	NCAW	0.1M HNO <sub>3</sub>	0.5M HNO <sub>3</sub>	Base Case Nitrate Elution Comparison
DA	60	18	NCAW	0.1M HNO <sub>3</sub>	0.5M HNO <sub>3</sub>	Replicate of Base Case Nitrate Elution
G	240	4.5	NCAW	0.1M HNO <sub>3</sub>	0.5M HNO <sub>3</sub>	Effect of Increased Flow Rate
J	120	9	NCAW	0.1M HNO <sub>3</sub>	0.3M HNO <sub>3</sub>	Reduced Nitrate Concentration for Cs Elution to Lower Caustic Neutralization Required
JA	120	9	NCAW	0.1M HNO <sub>3</sub>	0.3M HNO <sub>3</sub>	Replicate of J

(from Reference 27)

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The steps involved in running a feed batch through the ion exchange column are illustrated in Figure 4-8. The column is initially in a sodium loaded condition. As the feed is passed through the column, cesium and aluminum are exchanged onto the resin for sodium. When the resin is loaded with enough cesium so that breakthrough is seen, the feed is stopped. A flush solution is then used to assure that the acid sodium scrub does not contact the basic feed solution.

The intent of the sodium scrub is to exchange hydrogen for sodium on the resin, while using a nitric acid scrub solution that is weak enough that the hydrogen will not exchange for significant amounts of cesium. This helps achieve better separation of the sodium and cesium through the ion exchange process. The sodium scrub is followed by a stronger nitric acid eluant that removes the majority of the cesium and any residual sodium, aluminum, or any other +1 cation.

The final portion of the ion exchange process is to put the column back into the sodium loaded condition in preparation for another cycle. This regeneration step is performed by the addition of sodium hydroxide to the column, with the sodium ions replacing the hydrogen on the resin. To prevent excessive reaction rates and heat/gas generation, the sodium hydroxide is added first in a weaker 0.5 M solution, then in a stronger 2 M solution.

The composition of the IX synthetic feed recipe used in the tests is given in Table 4-9. This recipe was developed in 1984-1985 before samples were taken and analyzed from Tank 101-AZ and from the B Plant NCAW process test in November 1985 and May 1986 respectively (References 6 and 16). As such, the recipe did not include the +1 valence cations potassium (K) and rubidium (Rb) which were quantified in these recent analyses of NCAW. These additional cations compete with cesium for sites on the IX resin. Had they been included in the synthetic feed recipe used in the column loading tests, the amount of cesium that was loaded on the Duolite CS 100 resin before breakthrough might have been less. The volumes of sodium scrub and cesium eluant solutions required might have been different also. The composition of the IX synthetic feed recipe has been updated this fiscal year and will be used in future IX resin testing to determine the effect on the cesium capacity of the resin. This is discussed below in Section 4.4.4, "Ongoing/Planned Technology Work for Ion Exchange."

Using the original synthetic feed recipe shown in Table 4-9, several setup runs were made to get a feel for the volumes of solution required for the various stages, and to assure the test equipment was operating correctly. Then a number of tests were run to establish the process parameters, including the percentages of cesium, sodium, aluminum, and calcium adsorbed or removed from

Figure 4-8. Ion Exchange Process Schematic  
First Cycle Nitric Flowsheet

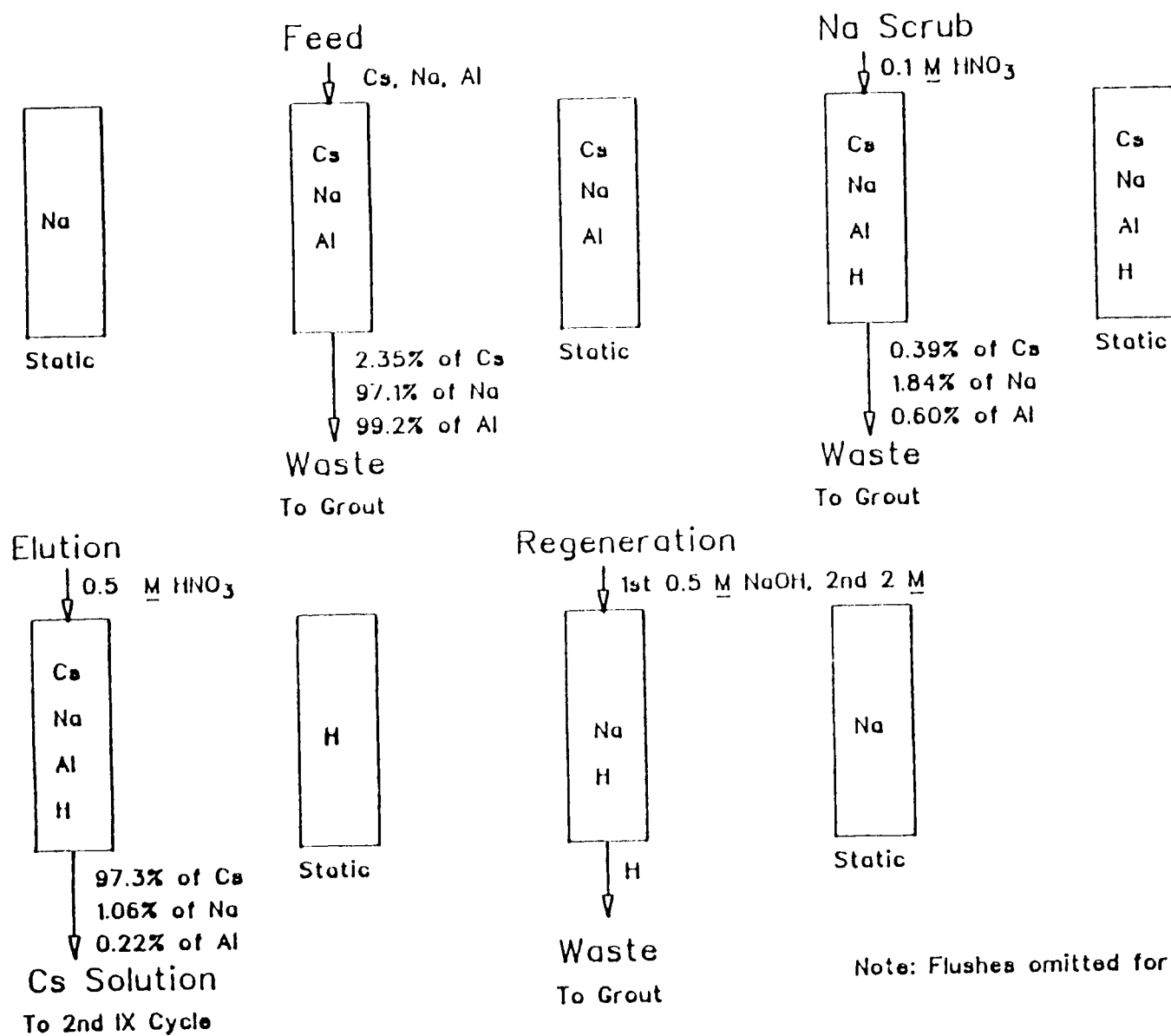


Table 4-9. Chemical Makeup for Synthetic  
Feed to Ion Exchange

Component	Molarity (M)
$\text{Na}_2\text{SO}_4$	0.089
$\text{NaF}$	0.032
$\text{HNO}_3$	0.198
$\text{NaOH}$	1.73
Free OH	0.476
$\text{Al}(\text{NO}_3)3.9\text{H}_2\text{O}$	0.264
$\text{Cr}(\text{NO}_3)2.9\text{H}_2\text{O}$	0.000077
$\text{CsNO}_3$	0.000737
$\text{Ca}(\text{NO}_3)_2$	0.000391
$\text{Fe}(\text{NO}_3)3.9\text{H}_2\text{O}$	0.000483

(pH = 13) (from Reference 27)

the column in each step. Table 4-10 gives the normalized removal percentages for the tests that were run. Table 4-11 shows the column volumes found necessary for each step in the first ion exchange cycle. Test runs were performed for the feed at both a normal lab flow rate and at a doubled rate to verify that velocity scaleup would have no effect on the cesium removal effectiveness.

Since the cesium stream is to be stored in B Plant, a second ion exchange cycle is needed to further separate the sodium from the cesium and allow the cesium to be concentrated to a small enough volume to fit into available storage space. Tests were also run to establish parameters for a second cycle of ion exchange for the nitric acid and ammonium carbonate eluant flowsheets.

Before beginning the second cycle ion exchange process it was necessary to neutralize the eluant from the first cycle, since the CS 100 resin requires a basic feed solution. In an effort to avoid using sodium hydroxide and increasing the sodium:cesium ratio, several anion exchange resins were tried but were ineffective in raising the pH of the solution. The addition of sodium hydroxide to neutralize the first cycle eluant to 0.1 M excess hydroxide was required.

Conditions for the second cycle tests are given in Table 4-12. The results of the second cycle tests are shown in Table 4-13 and 4-14. At the conclusion of the second cycle, the cesium removal efficiency for the total NCAW pretreatment process (cesium with PHP solids and cesium stored in B Plant) will be above 94%.

#### 4.4.2.1 Ammonium Carbonate Eluant Tests.

Tests were also run with ammonium carbonate used as the eluant as a backup process. The removal efficiencies are similar to those found for the nitric acid eluant, except for sodium which is higher for the ammonium carbonate eluant.

Table 4-15 shows the sodium:cesium ratios for the two eluants. This ratio is considerably better while using the ammonium carbonate eluant since the cesium product has a basic pH as feed to any subsequent IX cycle. Consequently, the cesium product does not need to be neutralized with sodium hydroxide as is required while using the nitric acid eluant. This required neutralization of the nitric acid prevents the nitric eluant flowsheet from ever attaining a product cation (Na+K+Rb):Cs mole ratio of 1:1. This ratio is

Table 4-10. Percent of Elements in First Cycle for HNO<sub>3</sub> Flowsheet Tests

FIRST CYCLE									
	Loading Waste and Flush			Na Scrub			Cs Elution and Flush		
Run	% Cs <sup>(1)</sup>	% Na	% Al	% Cs <sup>(1)</sup>	% Na	% Al	% Cs <sup>(1)</sup>	% Na	% Al
D	0.91	95.7	99.5	0.0	2.04	0.4	99.1	2.27	0.1
DA	0.54	83.0	82.0	0.09	1.33	0.3	99.4	15.7	17.8
G	3.75	90.4	92.5	1.19	8.3	7.45	95.1	1.34	0.09
J	2.3	97.3	99.6	0.34	1.73	0.34	97.4	0.95	0.09
JA	2.40	96.9	98.8	0.44	1.95	0.87	97.2	1.17	0.35

(from Reference 27)

(1) The percent with respect to the total amount of the particular element entering with the feed to the Ion Exchange column

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Table 4-11. Number of Column Volumes for First Cycle HNO<sub>3</sub> Flowsheet Tests

FIRST CYCLE								
Column Designation	0.5M NaOH	2M NaOH	H <sub>2</sub> O	Feed	H <sub>2</sub> O	Na Scrub	Cs Elution	H <sub>2</sub> O
Run D	1.0	2.0	1.0	45.0	2.0	8.0	6.0	4.0
Run DA	1.0	2.0	1.0	45.0	2.0	8.0	6.0	4.0
Run G	1.0	2.0	1.0	45.0	2.0	8.0	11.0	12.0
Run J	1.0	2.0	1.0	45.0	2.0	8.0	8.0	4.0
Run JA	1.0	2.0	1.0	45.0	2.0	8.0	8.0	4.0

(from Reference 27)

Table 4-12. Test Conditions for Second Cycle HNO<sub>3</sub> Flowsheet

SECOND CYCLE						
Run	Flow Rate (cm <sup>3</sup> /hr)	Residence Time (min)	Feed	Na Scrub	Cs Elution	Comments
SCA	120	9	0.5M Neut 2nd Cycle	0.1M HNO <sub>3</sub>	0.5M HNO <sub>3</sub>	Cs Eluate Concentrate Neutralized with 0.5M NaOH
SCC	120	9	0.5M Neut	0.1M HNO <sub>3</sub>	0.5M HNO <sub>3</sub>	Repeat of SCA
SCB	60	18	19.4M Neut 2nd Cycle	0.1M HNO <sub>3</sub>	0.5M HNO <sub>3</sub>	Cs Eluate Concentrate Neutralized with 19M NaOH
SCD	120	9	19.4M Neut	0.1M HNO <sub>3</sub>	0.5M HNO <sub>3</sub>	Repeat of SCB

(from Reference 27)

Table 4-13. Percent of Elements in Second Cycle HNO<sub>3</sub> Flowsheet Tests

SECOND CYCLE									
Loading Waste and Flush				Na Scrub			Cs Elution and Flush		
Run	% Cs <sup>(1)</sup>	% Na	% Al	% Cs <sup>(1)</sup>	% Na	% Al	% Cs <sup>(1)</sup>	% Na	% Al
SCA	19.9	121.2	62.5	7.35	ND	ND	72.8	ND	ND
SCC	1.84	90.41	1.3	1.43	5.17	27.04	96.7	4.42	71.7
SCB	30.0	88.3	48.1	21.5	9.97	37.0	48.6	1.76	14.8
SCD	1.03	76.4	ND	0.34	8.61	0.0	98.6	15.0	ND

(from Reference 27)

(1) The percent with respect to the total amount of the element in the feed

ND = Not determined or not detected

Table 4-14. Number of Column Volumes for Second Cycle HNO<sub>3</sub> Flowsheet Tests

SECOND CYCLE								
Column Designation	0.5M NaOH	2M NaOH	H <sub>2</sub> O	Feed	H <sub>2</sub> O	Na Scrub	Cs Elution	H <sub>2</sub> O
Run SCA	1.0	2.0	1.0	24.0	2.0	11.0	4.0	4.0
Run SCC	1.0	2.0	1.0	18.0	2.0	8.0	5.0	4.0
Run SCB	1.0	2.0	1.0	3.0	2.0	13.0	4.0	5.0
Run SCD	1.0	2.0	1.0	1.0	2.0	5.0	6.0	4.0

(from Reference 27)

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Table 4-14. Number of Column Volumes for Second Cycle HNO<sub>3</sub> Flowsheet Tests

SECOND CYCLE								
Column Designation	0.5M NaOH	2M NaOH	H <sub>2</sub> O	Feed	H <sub>2</sub> O	Na Scrub	Cs Elution	H <sub>2</sub> O
Run SCA	1.0	2.0	1.0	24.0	2.0	11.0	4.0	4.0
Run SCC	1.0	2.0	1.0	18.0	2.0	8.0	5.0	4.0
Run SCB	1.0	2.0	1.0	3.0	2.0	13.0	4.0	5.0
Run SCD	1.0	2.0	1.0	1.0	2.0	5.0	6.0	4.0

(from Reference 27)

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Table 4-15. Sodium to Cesium Mole Ratios

Solution (Na:Cs)	Nitric Flowsheet Ratio (Na:Cs)	Ammonium Carbonate Flowsheet, Ratio
NCAW (First Cycle Feed)	11,400:1	11,400:1
First Cycle Cesium Eluate	125:1	20:1
Neutralized Cesium Eluate (Second Cycle Feed)	280:1	-
Second Cycle Cesium Eluate	13:1	2:1

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required for the previous purification/encapsulation flowsheet that may possibly be restarted sometime in the future at the Waste Encapsulation and Storage Facility (WESF). The ammonium carbonate eluant flowsheet should permit a 1:1 ratio for the purification/encapsulation flowsheet after three IX cycles (Reference 26) and possibly after only two.

#### 4.4.3 Further Resin Tests due to Changes in Duolite CS 100

Since the supply of Duolite CS 100 resin had been almost depleted by the previous lab tests mentioned above, additional CS 100 resin was ordered and received in January 1987 to use for any further resin tests. Acid/resin degradation tests began about this time to prepare for the design of a new IX column for B Plant. This column was believed necessary due to the potential for accidental contact of concentrated nitric acid with the organic resin in the existing column which is not equipped to mitigate such an incident. Concern over this issue was raised in the original version of this flowsheet (Reference 28).

Upon receipt of the CS 100 resin, it was discovered that the as-received resin was lighter in color than the previous batch. In addition, data from batch contact tests with the synthetic NCAW IX feed indicated that the resin had a total Cs capacity of 0.0048 g Cs/g resin compared to the previous value of 0.0125 g Cs/g resin (Reference 29). The percent water analyses in the as-received hydrogen form indicated 59% versus 42% respectively. Subsequent conversations with the vendor, Rohm & Haas (R&H) revealed that the manufacturing process had been changed somewhat in 1982 while Diamond Shamrock Corporation still owned the Duolite IX resin product line (Reference 30). This change could have inadvertently modified some of the characteristics of the resin. The Duolite product line was sold to R&H in 1984. The resin used in batch and column tests as reported in the original August 1986 version of this flowsheet was of the pre-1982 CS 100 variety.

The resin received in January 1987 was of the post-1982 CS 100 variety. Due to concerns about the possible lower cesium capacity, duplicate IX column lab tests were run in March 1987 with the post-1982 resin to determine the loading, scrub, and elution characteristics compared to those of the pre-1982 resin. These tests were run just on the first cycle IX, using the synthetic IX feed recipe shown in Table 4-9.

The first cycle IX column lab tests showed that the Cs capacity of the post-1982 resin was about 0.0047 versus 0.006 g total Cs/g resin for the pre-1982 resin. This is about 78% of the previous capacity, considerably better than the 40% indicated by the batch contact tests. The 78% corresponds to only 35 column volumes of synthetic NCAW IX feed that could be loaded onto the post-1982 resin before cesium breakthrough compared to 45 column volumes with the pre-1982 resin (Reference 29). This reduced cesium capacity may still be adequate for the IX process since these lab results with the post-1982 resin indicated excess cesium capacity was available, more specifically about 600,000 Ci Cs-137 was theoretically available versus only 100,000 Ci Cs-137 called for in this flowsheet. However, the Na:Cs ratio in this flowsheet is about 11,000:1 based on recent TK-101-AZ data for NCAW (Reference 6). When this is compared to the smaller 2,600:1 Na:Cs ratio used in the synthetic NCAW feed recipe in the lab column tests, less than 600,000 Ci Cs-137 may be theoretically available, with less excess capacity available to load the 100,000 Ci Cs-137 called for in this flowsheet. Also, with the cations

potassium and rubidium absent from the feed, less excess capacity may be available to load cesium from actual feed which contains these additional, competing cations.

#### 4.4.4 Ongoing/Planned Technology Work for Ion Exchange

A limited amount of technology work for ion exchange has been recently approved and is underway during FY 1987. With the higher Na:Cs ratio anticipated in NCAW during demonstration processing than was used during the previous lab tests, an update of the IX synthetic feed recipe is necessary before any further lab tests are conducted. Also, the cations potassium, rubidium, and ruthenium (Ru) have been recently quantified in NCAW (References 6, 8, 16). These cations need to be added to the feed since they compete with Cs for sites on the IX resin and may limit the Cs capacity of the resin. This update of the IX synthetic feed recipe is currently underway (Reference 31). The updated recipe along with the original recipe (Table 4-9) for comparison are shown in Table 4-16.

To investigate a promising back-up IX resin, batch contact and elution tests will be performed with the updated synthetic feed and the new resorcinol-formaldehyde resin (Reference 32) being developed at Savannah River Laboratory (SRL). Duplicate tests will be conducted with this new resin. To serve as a comparison, like tests also will be run with post-1982 CS 100 resin and the previously used resin, Duolite ARC 9359 at identical conditions.

Duplicate column tests for first and possibly also second cycle IX are being considered with the post-1982 CS 100 resin using the updated synthetic feed (Reference 30). The Cs capacity, Na scrub, and Cs elution characteristics of the post-1982 resin may be significantly different in view of an updated Na:Cs ratio of about 11,000:1 versus 2,600:1 previously, and the presence of potassium and rubidium. The presence of ruthenium in the updated recipe also raises some questions. The accumulation/separation of ruthenium by the resin is of interest for both resin poisoning concerns and environmental emissions of ruthenium tetroxide ( $\text{RuO}_4$ ) out the E-20-2 Concentrator.

Formic acid is being considered as an alternate eluant to nitric acid. This weak, organic acid is a mild reducing agent unlike nitric acid which is a strong oxidizing agent, especially at concentrations above 3 M. It would not potentially react with the IX resin as nitric acid would, but larger volumes of formic acid eluant would be required.

Also under consideration for an IX back-up process is Duolite ARC 9359 resin. Since about 4,000 gal of this resin previously used at B Plant is still available, column tests with it are being considered using possibly dilute formic acid or nitric acid as the eluant. In addition to an OH- functional group, ARC 9359 also has a sulfonic acid group which makes it difficult to elute Cs from this resin with an acid unless large volumes of the acid are used. This explains the former use of ammonium carbonate as eluant for this resin at B Plant.

Table 4-16

## Composition of Ion Exchange Synthetic Feed Recipe

Component	Molarity (M)	
	Original Recipe (Ref. 27)	Updated Recipe (Ref. 31)
Na <sub>2</sub> SO <sub>4</sub>	0.089	0.068
NaF	0.032	0.039
HNO <sub>3</sub>	0.198	-----
NaNO <sub>3</sub>	-----	0.075
NaOH	1.73	1.58
Free OH <sup>-1</sup>	0.476	-----
Al(NO <sub>3</sub> ) <sub>3</sub> .9H <sub>2</sub> O	0.264	0.207
Cr(NO <sub>3</sub> ) <sub>2</sub> .9H <sub>2</sub> O	7.7E-5	5.3E-3
CsNO <sub>3</sub>	7.37E-4	2.0E-4
KNO <sub>3</sub>	-----	0.162
RbNO <sub>3</sub>	-----	1.5E-4
RuNO(NO <sub>3</sub> ) <sub>3</sub>	-----	6.0E-4*
Ca(NO <sub>3</sub> ) <sub>2</sub>	3.91E-4	5.4E-3
Fe(NO <sub>3</sub> ) <sub>3</sub> .9H <sub>2</sub> O	4.83E-4	-----
NaNO <sub>2</sub>	-----	0.195
Na <sub>2</sub> CO <sub>3</sub>	-----	0.104
Na <sub>3</sub> PO <sub>4</sub>	-----	0.011
Total Na	1.9	2.3
Na:Cs Mole Ratio	2,630	11,430

\*Assume 100% of the ruthenium is in the NCAW supernate.

#### 4.4.5 Resin Degradation Tests

A sample of the pre-1982 CS 100 resin was irradiated during FY 86 to  $10^8$  rad and contacted with synthetic feed solution to verify that irradiation damage would not degrade the resin's ability to adsorb cesium. No degradation effect was seen. Additional work was conducted during FY 87. No degradation effects were seen either after samples of the post-1982 Cs 100 resin were irradiated to  $5 \times 10^8$  rad and  $10^9$  rad. Also, a possible synergistic irradiation/nitric acid interaction effect which might chemically degrade the resin was studied, as well as tests on gas generation rates and heat buildup with concentrated nitric acid contact.

Concentrated 12.2 M nitric acid was reacted with the post-1982, NCAW-treated CS 100 resin in the unirradiated,  $5 \times 10^8$  rad irradiated, and  $10^9$  rad irradiated states. The irradiated resins produced less heat and gas than the unirradiated resin. Similar results were found when 6.1 M nitric acid was reacted with the pre-1982, hydrogen form (as-received) Cs 100 resin in the unirradiated,  $10^5$  rad, and  $10^6$  rad states (Reference 33). From these results it appears that irradiation of CS 100 resin does not increase the acid/resin reactivity but slightly reduces it for both 6.1 and 12.2 M nitric acid. In general, it was found that the post-1982 resin is less reactive than the pre-1982 resin.

During FY 86, samples of the resin were also soaked in nitric acid at 1 and 12 M concentrations for three days, at 60 °C, and then submitted for differential thermal analysis. The presence of exothermic reactions in the analysis would indicate that potentially explosive nitrogen based compounds might be formed by the resin in contact with the nitric acid, but no exotherms were found (Reference 34).

The laboratory did note that the resin contacted with 12 M nitric acid reacted vigorously, with a temperature increase and gas evolution. This should be expected, as the resin is a reducing agent and the nitric acid is a strong oxidizer. The resin is rated by the manufacturer for 1 M nitric acid service, but at stronger acid concentrations the resin will degrade, especially at elevated temperatures. During the 12 M contact test at 60 °C, all of the resin was dissolved within a few hours. About 6 weight% of the resin reacted in the test with 1 M nitric acid contact at 60 °C for three days. Earlier testing with 1 M nitric contact at ambient temperatures for a period of about 1 month showed no weight loss.

More extensive nitric acid/resin reaction lab tests were conducted during FY 87 with the pre-1982 CS 100 resin in the NCAW-treated, unirradiated state. The resin was tested at ambient temperature and at 60 °C in various acid concentrations from 0.5 to 12.2 M. At ambient temperature, little or no heat or gas was generated for nitric acid concentrations of 0.5 to 3.0 M while observed for about 30 minutes. As expected, extensive gas and heat were generated for multiple runs with 12.2 M acid, with the final reaction temperature reaching the 43 to 75 °C range. At 60 °C, no additional heat was generated, and very little gas was generated for 1.5 and 2.0 M acid reactions while observed for about 30 minutes (Reference 33).

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Additional nitric acid/resin reaction lab tests were conducted off-site in order to supply data for use in the design of the new T-18-2 IX column (Reference). Tests to determine the reaction rates and gas generation rates for various nitric acid concentrations at temperature and pressure were performed by Hazards Research Corporation (HRC) of Rockaway, New Jersey, using an accelerating rate calorimeter. With this equipment the potential for a thermal runaway reaction can be determined. Both unirradiated resin pretreated with synthetic NCAW feed and irradiated, pretreated resin were planned for testing. The data will be used specifically to determine venting requirements for the new column so that in the event of a resin/acid reaction the column and cell damage will be limited to the rupture disks. A preliminary report for the reaction with the unirradiated resin has been received from HRC (Reference 35) and is being evaluated, with the final report expected by the end of FY 87.

Since the nitric acid concentration selected for the process was deliberately held to the minimum that was successful in eluting the cesium and scrubbing sodium from the resin, 0.3 M and 0.1 M nitric respectively (0.5 M for second IX cycle cesium eluant), no significant resin degradation in the process is expected. This conclusion is based on the laboratory tests discussed above and the resin technical specifications which lists a maximum nitric acid concentration of 1 M at 25 °C. However, precautions must be taken in the plant to assure that nitric acid of 1 M concentration or greater is not introduced to the column. These are discussed below in Section 8.5, "Nitric Acid - Organic Resin Reaction". Since the oxidizing reaction rate increases at higher temperatures, the temperature of the column must be monitored whenever nitric acid eluant is used and free flowing conditions for maximum cooling should be maintained. Nitric acid should not be allowed to stand stagnant in the column.

#### 4.4.6 NO<sub>x</sub> Emissions Considerations

Concentrator simulation lab experiments conducted during FY 1986 indicate that only small amounts of NO<sub>x</sub> should be emitted from the Cs product concentrator (E-20-2) and the loading waste concentrator (E-23-3). Lab analyses for the NO<sub>x</sub> that was generated in the experiments indicate that even with both concentrators running simultaneously, less than 10 ppm (well below the 200 ppm instantaneous level) total NO<sub>x</sub> from these two sources combined should be emitted through the Vessel Vent 2 system exhaust (Reference 36). These results seem reasonable when considering the relatively low temperatures present in these two concentrators, since NO<sub>x</sub> formation usually occurs at temperatures significantly higher than 100°C.

Possible additional NO<sub>x</sub> could form upon the sodium hydroxide neutralization of the nitric acid present with the sodium scrub waste in Tank TK-24-1. This amount should be small when considering that only 3.5 E-3 M nitric acid is present with the sodium scrub exiting the IX column.

#### 4.5 KEY ASSUMPTIONS FOR VERIFICATION IN DEMONSTRATION

A number of the process parameters have key significance in determining the process performance and control values. These parameters are identified below for the various unit operations. During the demonstration, the values of these key assumptions should be verified, and where the parameter can be varied, the effects of controlled changes should be included in assessing which assumptions have the highest priority for further verification and testing during demonstration.

##### 4.5.1 Settle/Decant Processing

- o **Settling Rate:** The hindered settling rate of the actual NCAW with 4 vol% settled solids was conservatively assumed to be 5 cm/hr (2 in/hr). A faster settling rate could allow only one set of settling tanks to meet throughput requirements and simplify routing.
- o **Flocculating Agent:** The use of ferric nitrate as a flocculating agent was assumed to be necessary to attain settling rates of 5 cm/hr (2 in/hr) or greater. The settling aid may not be needed if settling rates of the retrieved NCAW are significantly higher than the conservative assumption. However, the possibility that NCAW with higher solid levels could be retrieved during production processing must be considered.
- o **Washing Efficiencies:** The washing efficiencies for the soluble components must be confirmed to assure that glass feed specifications can be met. If necessary, washing at higher wash ratios can be performed with little effect on the settle/decant throughput time, but the extra wash water would increase concentrator time cycles and the BCP condensate volume.
- o **Jet Leg Height Above Settled Solids:** A 23 cm (9 in) distance above the settled solids for the decant jet dip leg was selected. This is about 4-1/2 pipe diameters, and the pilot plant tests showed 2 pipe diameters was adequate. If the settled solids are disturbed by the decanting process, higher solids in the PHP feed could be expected. Using a larger distance would decrease washing efficiencies for the soluble components.

##### 4.5.2 PHP Filter Processing

- o **Filtrate Rate:** A filtrate rate of .3 gal/min/ft<sup>2</sup> was assumed. A significant reduction in the ability of the PHP filter to meet this rate could reduce cycle times and increase the amount of diatomaceous earth going to glass.
- o **Cycle Length:** A cycle length of 32,300 L (8,500 gal), was conservatively assumed to match settle/decant and IX processing needs. Pilot plant data suggests that up to 60,900 L (16,000 gal) of feed could actually be processed, and the WESF process test indicated even higher cycle lengths could be achieved.
- o **Filter Cleaning:** No significant plugging and required cleaning of the PHP filter is forecast. Should the PHP filter require frequent cleaning cycles and exhibit decreased filtrate rates the PHP could become a bottleneck between settle/decant and IX operations. Larger backflushes with water would not degrade separations efficiency but would require more chemical additions to meet tank corrosion specifications, thus contributing more Na to the glass feed.

#### 4.5.3 Ion Exchange Operations

- o Amounts of Key Components in the Feed: The amounts of Cs, Na, K, and Rb in the feed are important in the split of these components through the ion exchange process. They compete against each other for resin sites on an equilibrium basis that changes as their ratios to each other change. In addition, the concentration of Cs establishes the total amount of feed that can be loaded for the first IX cycle. A higher Cs concentration than that assumed would allow storage of more first cycle concentrated cesium batches before second IX cycle operations and the final ratio of Na:Cs would be less.
- o Splits of Cs, Na, K, and Rb Through IX Operations: The separation efficiencies for these components, given in the technology section on IX, should be verified during demonstration processing. If the amount of Cs in the waste streams is high enough to exceed grout specifications, or the amounts of Na or K in the eluate are significantly above those assumed, adjustments in the scrub or eluant strengths or other process changes may be indicated.
- o Amount of Ru in the Eluate: The amount of Ru that follows the first cycle cesium eluate should be determined, and the amount that volatilizes in the E-20-2 Concentrator verified. Since Ru is a +2, +3 ion, it should not follow the Cs stream, but if significant quantities were seen in the acid stream to the concentrator, the Ru could volatilize and enter the Vessel Vent 2 system, and eventually be released.
- o The 0.3 M and 0.5 M nitric acid concentrations for first and second cycle cesium elution should be verified. A 0.3 M nitric concentration would probably provide adequate elution for the second cycle but was not tested in the laboratory. If it has not been lab tested before demonstration, a demonstration run at the lower concentration should be tried.

#### 4.5.4 Concentrator Operations

- o Concentration of Low Level Wastes: The concentration process will be controlled by specific gravity in the E-23-3 Concentrator. This will need to be correlated with waste sample results while considering premature precipitation of solids and sodium concentration. The latter sample result is a process control parameter specified in Section 5.0 of this document. Tank farm storage volume requirements can be minimized by concentrating up to 5 M Na if possible.
- o Concentration of First Cycle Eluate: A final Na Concentration of 2.5 M was assumed based on the laboratory tests. The volume of the first cycle eluate is dependent upon this concentration. Since lag storage available for the concentrated eluate limits the number of first cycles before a second IX cycle must be performed, a concentration above 2.5 M would improve the process time cycle.
- o Ability to recycle the nitric acid in the E-20-2 Concentrator was assumed, with a 100% recovery and a startup with 4.2 M nitric in the concentrator. This should be verified in demonstration as it is based primarily on calculations of the concentrator operations.

- o The amount of  $\text{NO}_x$  emitted from Tank TK-24-1 upon the sodium hydroxide neutralization of the nitric acid in the sodium scrub is expected to be small out the Vessel Vent 2 system and within release limits. This is also expected to be the case for the  $\text{NO}_x$  from concentrator E-20-2 and E-23-3. This should be verified during the demonstration.

## 5.0 PROCESS CONTROL

### 5.1 FEED RECEIPT AND CHARACTERIZATION

Feed will be received from TK-101-AZ as described in Reference 5, the flowsheet for NCAW retrieval for the demonstration. The composition of the feed will be determined by analysis of a sample from each 53,000 L (14,000 gal) transfer batch at B Plant (see sample schedule in Section 5.5). The solids level in the feed for demonstration is expected to be approximately 4 vol% settled solids based on the B Plant process test characterization results.

The key parameters for the feed receipt are given below, and also discussed in detail in the flowsheet for the demonstration retrieval of NCAW, Reference 5.

- o Feed batch size: 53,000 L  $\pm$  4,660 L / -1,900 L  
(14,000 gal  $\pm$  1,230 gal / -500 gal)

The feed batch must fit into TK-11-2, TK-8-2, TK-8-1, and TK-9-2 with a total working capacity of 57,600 L (15,230 gal). Excessive size of the feed batch would fill tanks beyond their working limit, so the feed batch must be terminated before this occurs. Occasional low feed batch size would have little detrimental effect but frequent low batch sizes would not provide the proper batch sizes for TK-8-1 and TK-9-2 and would affect throughput rates.

- o Flush size: 10,070 L  $\pm$  760 L / -380 L  
(2,660 gal  $\pm$  200 gal / -100 gal)

Control of the flush volume is important to assure transfer line cleanout. Low flush volumes could result in solids buildup in the line and eventual line pluggage. High flush volume is not critical.

- o Flush transfer rate: 280 L/min  $\pm$  95 L/min  
(75 gpm  $\pm$  25 gpm)

The flush transfer rate must be above 50 gpm to assure that solids will not settle. In addition, the flush transfer must be initiated within 15 minutes of completion of the feed transfer, to prevent solids from settling in the NCAW remaining in the transfer line.

- o Temperature of transfer: <50 °C

While B Plant has no direct control over this parameter, it is critical to assure that incoming feed to TK-11-2 can be transferred by jet to TK-8-2 and TK-9-1. The tank farm demonstration retrieval flowsheet specifies that AR Vault operations must assure the solution temperature is less than 50 °C before starting a transfer, but temperature monitoring by B Plant operations should be maintained.

## 5.2 SETTLE/DECANT PROCESS CONTROL

The key parameters in the settle/decant process are the amount of settled solids and the settling rate of the solid/liquid interface. The amount of settled solids will be monitored on a transfer batch basis as NCAW feed is transferred into B Plant. The level of solids is not expected to change significantly from batch to batch, but it may change by the end of the demonstration or during production retrieval operations. A significant change could require an adjustment in the feed batch size or in the length of the jet dip leg(s) in the settle/decant tanks. A special jet dip leg is planned for use in the demonstration. It will have four dip legs of various heights incorporated to allow for the possibility of changing solids levels in the feed.

The settling rate of the solid/liquid interface can only be indirectly monitored by the clarity of the decantate removed after the specified settling time. Optimizations to determine the solid/liquid interface location in real time are also candidates for demonstration tasks. Possible control devices include ultrasonic interface detectors, conductivity probes, and neutron monitoring instruments. A technology Program Plan (Reference 37) includes tasks to assess the feasibility of these devices and develop plant control equipment.

The initial process control will be by sampling of the decantate streams to determine solids levels and total alpha radiation concentration before polishing filtration proceeds. A normal solids level in the decantates is expected to be 100-300 ppm. Decantate batches with solid levels above 300 ppm will require rework through the settle/decant cycle or an adjustment of the polishing filtration process to add more DE. Based on the pilot plant work, solid levels below 1,000 ppm can readily be processed through the PHP filter.

- o Decant rate: 96 L/min jet rate +/- 19 L/min  
(25 gpm +/- 5 gpm)

Substantial variation in decant rate may be acceptable, based on the pilot plant tests of decantation with close approach of the jet dip leg to the solids showing no appreciable solids pickup. A jet rate of 96 L/min (25 gpm) was chosen to be conservative and because the decant period is not a large

component of the time cycle. This parameter should be varied during demonstration to determine if higher rates cause excessive solids carryover to the decantate streams.

- o Primary Settling Feed batch size: 15,520 L +/-380 L  
(4,100 gal +/-100 gal)

An undersized feed batch will result in inefficient use of the primary tank space and excessive washes relative to the amount of solids in the wash tanks but will not give poor product stream quality.

- o Solids in the feed: 4 vol% settled solids

Up to 5.2 vol% settled solids can be accommodated by the conservative wash volumes specified without degrading the washing efficiencies significantly. Above 5.2 vol% up to 9 vol% washing efficiencies may change slightly and an analysis should be performed to assure glass specifications (Table 5-1) can be met. Above 9 vol% settled solids, the solids level is closer than 2 pipe diameters to the jet dip leg, and either the feed batch size must be adjusted or the jet dip leg height changed.

All components are predicted to be adequately washed by the flowsheet wash conditions except for TOC. The results of the recent B Plant Test, discussed in section 4.2.2, showed that TOC did not behave as a soluble component in a washing test, and TK-101-AZ characterization shows that only about a third of the TOC is found in the supernate. The issue of TOC levels in NCAW feed will be addressed in analytical development efforts in FY 88 to determine if the predicted levels are high. Discussions between the HWVP Systems Group and Waste Management Systems have been initiated to determine whether the TOC specification for glass feed can be raised, or whether alternate actions need to be taken.

- o Settling time in the primary tank: 64 hours (low solids feed)  
Settling time in the wash tank: 11.2 hours (low solids feed)

Settling time in the primary and wash tanks should be controlled to assure the required settling has occurred, no variation on the low side is acceptable. Decanting before the solids have completely settled would cause solids carryover to the polishing filter. Variation on the high side in settling time affects throughput rates.

### 5.3 PNEUMATIC HYDROPULSE FILTER PROCESS CONTROL

The PHP filter will be run under computer control, with the main control parameters being the filtrate rate and the differential pressure across the sintered metal filter. The computer control will first precoat the filter, then slowly ramp up the feed flow at the beginning of the solids loading cycle to build a good solids cake without high pressure fluctuations. The flow rate will be controlled by a throttle valve on the filtrate side of the filter.

Table 5-1. Glass Feed Specifications

Component	Maximum Elemental Wt% Limit
Al	20.7
Na	23.4
F	2.9
S	1.1
P	3.2
Cr	1.9
TOC (Total Organic Carbon)	7.1

Based on Reference 38 (revised specifications are being drafted and may provide tighter limits)

Pilot plant experience showed that control from the filtrate side was easier to maintain, while throttling the feed flow from the pump side could cause large pressure variations that could be detrimental to a good solids cake buildup.

If the filtrate rate drops below 0.3 L/min/ft<sup>2</sup> or the differential pressure across the filter media goes above 35 psi, the computer control will shut off the feed and begin the backpulse cycle to remove the solids cake from the filter. Normally, the entire feed batch of 34,250 L (9,050 gal) will be processed before the loading cycle is stopped and the backflush cycle started. Based on the pilot plant data, up to 60,560 L (16,000 gal) of feed could be run through the PHP in a loading cycle, using the 42 g/ft<sup>2</sup> precoat and 1:4 diatomaceous earth body feed:solids ratio selected for the process. The 34,250 L (9,050 gal) batch size is specified to match the settle/decant process decantate output volume to the ion exchange process.

The filtrate from the PHP filter will be sampled for the solids level and total alpha content to verify the required solid/liquid separation efficiency has been achieved. A level of less than 54 ppm solids in the filtrate, assuming the transuranics are homogeneously distributed on the solids, is required for the recommended target maximum of 50 nCi/g TRU in grout. This corresponds to 1.1E-05 g/L of plutonium and 1.1E-05 g/L of americium in the filtrate from the PHP. Exceeding these levels will require the filtrate to be recycled for further polishing. The limits on amounts of other components in the filtrate are based on the specifications given in Table 5-2 (from Reference 38). Exceeding these limits will require interface with the grout project to determine if corrective measures are required.

Key process control parameters for the PHP operations are given below.

- o Filtrate rate : 76 L/min (+/- 10 L/min)  
(20 gpm +/- 2.6 gpm)

Decreased filtrate rates resulting from throttling down the feed will not have significant adverse affects on the filtrate quality, but will require longer run times. High filtrate rates from excessive feed rates will cause shorter cycles and may prevent completing a feed batch. Higher feed rates can compress the solids cake and create higher filter pressure differentials, and could also lead to more potential to plug the filter. No effect on filtrate quality from high feed rates is expected.

- o Precoat amount : 2.9 kg/batch +/- 0.7 kg/batch  
(6.4 lbs/batch +/- 1.5 lbs/batch)

The precoat amount should be closely controlled to assure that good filter performance can be maintained. With low amounts or no precoat, the cycle time of the filter is dramatically reduced, and the potential to plug the filter with solids increased. The PHP computer control system must include interlocks to assure precoat and body feed additions are complete before feed to the PHP filter is initiated. High precoat amounts are not detrimental to filtrate quality, but contribute to added waste oxides to HWVP and to solids slurry volume that must be stored in the tank farms.

Table 5-2. Grout Feed Specifications

Major Radionuclides (Worst Case Source Term)	In Grout Feed (Ci/L)	In PHP Filtrate (Ci/L)
<sup>60</sup> Co	0.21	0.015
<sup>90</sup> Sr	0.30	0.021
<sup>106</sup> Ru/Rh	0.70	0.54
<sup>125</sup> Sb	0.88	0.61
<sup>144</sup> Ce/Pr	1.01	0.70
<sup>137</sup> Cs/Ba	0.338	N/A
<sup>134</sup> Cs	0.507	N/A

- o Diatomaceous earth body feed : 1:4 diatomaceous earth to solids ratio (range 1:4.5 to 1:3.5)

High body feed additions have no detrimental effects on the operations of the PHP filter, in fact at body feed ratios of 1:2 larger feed batches could possibly be loaded and longer cycle times obtained. However, a larger feed batch is not needed and the higher body feed ratio does contribute to increased waste oxides to HWVP, therefore the upper limit of body feed addition has been set at a 1:3.5 ratio. Low body feed can affect the PHP operations, decreasing the loading cycle length and reducing the feed batch size. Cycle times in pilot tests with precoat but no body feed showed about a factor of five reduction in cycle times. Also, low body feed additions could contribute to an increased potential for plugging the filter with solids.

- o Feed batch size: 34,250 L/cycle +(see below)/-1500 L/cycle (9,050 gal/cycle -400 gal/cycle)

The feed batch size may be increased to about 60,900 L (16,000 gal) based on the pilot plant tests, or even up to 220,000 L (57,000 gal) based on the B Plant Process Test. An increase in the batch size reduces the ratio of the solids processed to the 130 L (34 gal) of filtrate with soluble components that is backflushed out with the solids and thus slightly decreases the amount of waste oxides to glass. A decrease in the batch size gives the opposite effect.

#### 5.4 ION EXCHANGE PROCESS CONTROL

The ion exchange loading cycle is controlled by the column cesium loading established in the lab tests, and by the in-cell gamma detector which monitors for cesium breakthrough in the loading waste stream. The normal operation of the ion exchange column will be to run a 112,000 L (29,600 gal) batch of feed through the column for the first cycle of the nitric acid flowsheet. This amount of feed should be loaded without significant cesium breakthrough. However, if the gamma monitor indicates that cesium activity is present in the loading waste effluent, the loading cycle must be stopped. Then the scrub, elution, and regeneration sequence must be initiated.

Feed rate to the ion exchange column from TK-18-3 will be 114 L/min (30 gal/min) based on the pump capacity and the process rates needed to best match the settle/decant, PHP, ion exchange and concentration operations. The column will be loaded with 235 cubic feet of the as-received, hydrogen form resin (328 cubic feet of the sodium form resin).

The concentration of the sodium scrub and cesium elution streams are based on the laboratory work for the CS 100 resin. The actual process variations in the molarity of the nitric acid that can occur without affecting the process efficiency have not yet been established. However, it is important not to let the scrub solution nitric acid content vary significantly above the 0.1 molar specified, or there is a potential for scrubbing cesium into the waste stream. For the cesium elution, variation in nitric concentration on the high side is not as critical, until a concentration above 0.5 molar is reached. While the resin is rated for service in 1 molar nitric, and the lab tests support this limit, it is more conservative to set the upper limit for the nitric acid eluants (1st and 2nd cycle) as close as possible to the specified average process control parameters.

Process control for the sodium scrub, cesium elution, and regeneration, is based on volumes to the IX column and verified by downstream sampling of the combined waste streams and the cesium product stream. Sampling of these streams after concentration and before transfer to tank farms for storage is required to verify that hydroxide concentration is above 0.01 M and nitrite concentration is above 0.011 M (References 38 and 39). Addition of NaOH or NaNO<sub>2</sub> is required when the minimum tank farm limits are not met. Concentrated low-level waste product that does not meet the cesium limits may need to be recycled through the ion exchange process. The key process control parameters for the ion exchange process are:

- o First cycle feed batch size: 112,000 L +/-3,400 L  
(29,600 gal +/-900 gal)

The feed batch size should load 100,000 Ci of <sup>137</sup>Cs on the column. Low batch sizes will load less, and the volume ratio of feed to the scrub, eluant, and regeneration streams will decrease, resulting in increased process costs and reduced throughput. Product quality, however, should not be degraded. High volume feed batches could load beyond the column capacity and cause cesium breakthrough, which will be detected by the gamma monitor. Limiting the feed batch to 29,600 gal should prevent excessive cesium loss due to inadvertent high batch size or higher than expected cesium levels in the feed.

- o Second cycle feed batch size: 12,500 L +/-750 L  
(3,300 gal +/-200 gal)

The second cycle feed batch is intended to load 7.8E+5 Ci of <sup>137</sup>Cs on the column, and is the combined concentrates from eight 1st cycle cesium elution batches. The effects of variations in the feed batch size on the second IX cycle are similar to those given above for the first IX cycle.

- o Scrub, eluant, and regeneration batch sizes: as given in section 3.0, +/-200 gal
- o Sodium scrub solution concentration: 0.1 M nitric acid  
+/-0.01 M

The effect of low sodium scrub molarity would be to ineffectively remove sodium and thus lead to poor Cs:Na separation. The additional sodium that would then be in the eluate stream would contribute to added volume of the final cesium solution to be stored in B Plant, and to added glass volume and cost. Scrub solution with high molarity could remove cesium from the resin and increase the amount of cesium in the low-level waste stream, which must meet grout specifications.

o Cesium eluant addition: First cycle: 0.3 M nitric acid  
+/-0.03 M

: Second cycle: 0.5 M nitric acid +/-0.05 M

A low concentration in the first cycle eluant could lead to inadequate removal of the loaded ions from the column and affect the subsequent loading cycles by taking up resin sites. This could result in high or premature cesium losses on subsequent loading cycles and possibly contribute to a loss of cesium to the regeneration waste stream. Concentrations of eluant up to 1 M should have no adverse effect on the cesium removal from the column or may even contribute to a more complete removal of cesium to the eluate, but on the first cycle the additional nitric must be neutralized and thus contributes to a larger amount of sodium in the final cesium stream. Concentrations above 1 M are a safety concern due to the potential for nitric acid resin reactions, as discussed in Section 8.0, and engineering and administrative controls to prevent nitric acid concentrations above 1 M from introduction into the IX column are required.

o Concentration of Low Level Wastes: 5 M Na, +/- 0.5 M

All low-level waste streams, including the loading waste and associated flushes, sodium scrub solution and flush, and the regeneration solution and flush, are concentrated to 5 M sodium to minimize storage volume requirements. Concentrating above this limit, especially for the loading waste, could result in the precipitation of solids, affecting concentrator operations adversely. The concentration process will be controlled by specific gravity in the concentrator after this has been correlated with waste sample results. Initial demonstration runs will be controlled on the basis of volume. A concentrator upper limit of 1.17 spg must be observed, and this may be a limiting factor as the NCAW feed supernate spg is typically 1.15 to 1.18 at 5 M Na.

o First Cycle Cesium Product Neutralization: 0.1 M OH-, +/-0.03

If the OH- molarity is not adjusted sufficiently upward for neutralization in the acidic first cycle cesium product, the amount of cesium that will load on the IX resin bed will be limited. This could result in excess cesium losses requiring additional rework. Conversely, large additions of sodium hydroxide add excess sodium to the second cycle IX feed which will increase the cesium product storage volume and processing costs for HWVP.

## 5.5 SAMPLING REQUIREMENTS

A sample schedule for the process control at B Plant is given in Table 5-3. Major control points are in the feed receipt tank, the TRU solids tank, the decantates before feeding to the PHP filter, the final cesium solution, and the concentrated low level waste stream. The Analytical Development Plan for NCAW pretreatment at B Plant includes analytical techniques for this process control as well as to satisfy HWVP and Grout Program needs. (Reference 40)

Table 5-3. Sample Schedule for Demonstration Processing

Component/Analysis	Feed Receipt (TK-11-2)	Solids Slurry (TK-25-1)	Decantates (TK-33-1)	PHP Filtrate (TK-34-1)	Cesium Solution (TK-37-1)	Low-Level Waste (TK-25-2)
<u>Physical Analyses</u>						
Vol% solids-settled	X		X			
Vol% solids-centrifuged	X		X			
Weight% solids	X		X	X		
Specific gravity	X	X	X	X	X	X
Viscosity	X		X			
<u>Chemical Analyses</u>						
OH	X	X				X
PO <sub>4</sub>	X	X				X
SO <sub>4</sub>	X	X				X
NO <sub>3</sub>	X	X			X	X
NO <sub>2</sub>	X	X				X
CO <sub>3</sub>						X
TOC	X	X				
Na	X	X			X	X
Al	X	X			X	X
K	X	X			X	
Rb					X	
Ru					X	X
Ca	X	X			X	
Cr	X	X				
Mg		X				
P	X	X				X
Si		X				
Zr		X				
Cs		X			X	X
Ba		X			X	X
Ti		X				
Fe	X	X				
F	X	X				X

Table 5-3. Sample Schedule for Demonstration Processing (Continued)

Component/Analysis	Feed Receipt (TK-11-2)	Solids Slurry (TK-25-1)	Decantates (TK-33-1)	PHP Filtrate (TK-34-1)	Cesium Solution (TK-37-1)	Low-Level Waste (TK-25-2)
<u>Radionuclide Analyses</u>						
Total Beta	X					X
Total Alpha	X		X			X
<sup>90</sup> Sr						X
<sup>95</sup> Zr						X
<sup>106</sup> Ru						X
<sup>137</sup> Cs	X				X	X
<sup>137</sup> Ba	X				X	X
<sup>147</sup> Pm						X
<sup>239</sup> Pu				X		X
<sup>241</sup> Pu				X		X
<sup>241</sup> Am				X		X
Sample Frequency: TK-11-2 - every 7 days						
TK-25-1 - every 7 days						
TK-33-1 - every 5 days						
TK-34-1 - every 5 days						
TK-37-1 - every 15 days						
TK-25-2 - every 8-16 hours						
All analyses, unless noted otherwise, are to be done on the total slurry, supernate, water contacted solids, and acid contacted solids. Samples from tanks TK-33-1, TK-37-1, and TK-25-2 are expected to have low solids, and analyses for samples from these tanks may be done on acid contacted slurries.						

## 6.0 OFF STANDARD CONDITIONS

Table 6-1 lists some of the potential off standard conditions that could be encountered during processing of NCAW at B Plant. Suggested corrective actions are given for each off standard condition. The use of the computer simulation of the process could prove very valuable in assessing some of these conditions. The key parameters that affect different parts of the process can be easily changed to observe the downstream effects, in an effort to simulate problems and pinpoint likely causes.

## 7.0 PROCESS EQUIPMENT DESCRIPTION

The major processing equipment used for the NCAW pretreatment process at B Plant consists of process vessels, scale tanks, an inverted pneumatic hydropulse (IPHP) filter, and transfer jumpers/jets/pumps. These are described below for the demonstration flowsheet given in Reference 1. The settling tanks in Cell 9/30 are identified at this time as the second settling train, but this selection may change dependent upon jumper fabrication needs and funding. Detailed equipment descriptions are available in ISO-100 (Reference 41), the B Plant Safety Analysis Report (Reference 42) and as-built drawings.

### 7.1 PROCESS VESSELS (see Tables 7-1 through 7-2 and Figure 7-1)

Table 6-1. Off Standard Conditions

## Settle/Decant Section

Potential Conditions	Possible Causes	Suggested Corrective Actions
Low Solids in Feed from AR Vault	1. AR Vault agitator(s) shut down.	1. Check agitator status to ensure adequate mixing before transfer.
High TRU in Decant	1. Settled solids level higher than expected.	1. Recheck Feed Characterization, recycle, and use shorter jet dip leg if needed.
	2. Settling rate too slow.	2. Check if flocculating agent was added, recycle if required. Allow more settling time if needed.
	3. Settled solids have been resuspended, agitator on.	3. Recycle, do not agitate before decanting.
	4. Decant transfer route contaminated with solids.	4. Flush decant transfer route.
	5. Instrument malfunction	5. Repair TRU monitor.
	6. Error in sample analysis	6. Rerun sample and/or resample.
High Sulfate and Other Soluble Salts in the TRU Solids Stream	1. Inadequate wash volume.	1. Check for correct volume, check feed characterization. Recycle and rework to specifications.
	2. Recontamination.	2. Recycle, flush routes.
	3. Insufficient agitation.	3. Allow more agitation time.
Inefficient Jet Operation	1. Low steam supply.	1. Ensure adequate steam flow.
	2. Solution temperature >50°C.	2. Use cooling coils to cool solution.

Table 6-1. Off Standard Conditions (Continued)

PHP Filter Section

Potential Conditions	Possible Causes	Suggested Corrective Actions
High dP Across the PHP Filter and/or Short Loading Cycles	<ol style="list-style-type: none"> <li>1. Inefficient precoat or body feed addition of DE.</li> <li>2. Higher than expected solids in feed.</li> <li>3. Solids entrapped in sintered metal filter.</li> </ol>	<ol style="list-style-type: none"> <li>1. Assure proper precoat and body feed are being applied.</li> <li>2. Sample feed and recycle to settle/decant process if required.</li> <li>3. Nitric acid washing of the PHP filter may be required to clean solids from the sintered metal pores and maintain filter performance.</li> </ol>
High TRU and/or Sr in PHP Filtrate	<ol style="list-style-type: none"> <li>1. Causes and corrective actions as above for high dP.</li> <li>2. Broken filter element.</li> </ol>	<ol style="list-style-type: none"> <li>2. Replace broken filter element.</li> </ol>

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Table 6-1. Off Standard Conditions (Continued)

## Ion Exchange Section

Potential Conditions	Possible Causes	Suggested Corrective Actions
Short IX Cycles or Excessive Cs in IX Loading Waste Stream	<ol style="list-style-type: none"> <li>1. Faulty gamma analyzer.</li> <li>2. Exceeding bed loading capacity for Cs, due to high feed volume or loading of column with K, Rb.</li> <li>3. Degradation of resin.</li> <li>4. <math>&gt;0.1M</math> <math>HNO_3</math> in sodium scrub.</li> <li>5. Inefficient elution on prior batch.</li> <li>6. Channeling in IX bed.</li> <li>7. Broken support screen.</li> <li>8. For 2nd Cycle IX, insufficient neutralization of 1st cycle Cs product.</li> </ol>	<ol style="list-style-type: none"> <li>1. Fix gamma analyzer.</li> <li>2. Check volume fed to column. Recycle loading waste if required. A special regeneration may be required to regain loading capacity. May need to reduce feed flowrate.</li> <li>3. Investigate need to replace resin.</li> <li>4. Ensure sodium scrub is <math>0.1M</math> <math>HNO_3</math>.</li> <li>5. Provide proper <math>HNO_3</math> concentration and volume for next elution.</li> <li>6. For next regeneration and flush, provide proper upflow conditions to redistribute and "fluff" bed.</li> <li>7. Reduce feed batch size until repair of screen.</li> <li>8. Recycle loading waste after assuring <math>0.1M</math> <math>OH^-</math> for IX feed.</li> </ol>

Table 6-1. Off Standard Conditions (Continued)

## Ion Exchange Section (Continued)

Potential Conditions	Possible Causes	Suggested Corrective Actions
High Na Concentration in Cs Product Solution	<ol style="list-style-type: none"> <li>1. <math>&lt;0.1M</math> <math>HNO_3</math> in sodium scrub</li> <li>2. High Na concentration in NCAW and in IX feed.</li> </ol>	<ol style="list-style-type: none"> <li>1. Neutralize to <math>0.1M</math> <math>OH^-</math> and then recycle. Assure <math>0.1M</math> <math>HNO_3</math> for next sodium scrub.</li> <li>2. Decrease feed batch size.</li> </ol>
Excessive Cs in Regeneration Waste Stream	<ol style="list-style-type: none"> <li>1. Low <math>HNO_3</math> molarity of eluant or low eluant volume.</li> </ol>	<ol style="list-style-type: none"> <li>1. Recycle and assure proper conditions during next elution.</li> </ol>
High dP Across IX Column	<ol style="list-style-type: none"> <li>1. Inadequate water flush between regeneration and loading steps, leading to formation of aluminum precipitates.</li> <li>2. Packing of resin bed.</li> <li>3. IX resin degeneration/swelling.</li> </ol>	<ol style="list-style-type: none"> <li>1. Check water flush volume. Flush column upflow thoroughly with water to remove solids.</li> <li>2. Flush column upflow thoroughly with water.</li> <li>3. Investigate need to replace resin/ do upflow NaOH regeneration.</li> </ol>
Temperature Increase in IX Column During Regeneration/Elution	<ol style="list-style-type: none"> <li>1. Stage 1 regeneration solution greater than <math>0.5M</math> NaOH.</li> <li>2. <math>&gt;1M</math> <math>HNO_3</math> to column during elution.</li> </ol>	<ol style="list-style-type: none"> <li>1. Stop regeneration, flush column, check regeneration solution.</li> <li>2. Stop elution and flush column with water.</li> </ol>
Increased Pressure In IX Column	<ol style="list-style-type: none"> <li>1. <math>&gt;1M</math> <math>HNO_3</math> to column</li> </ol>	<ol style="list-style-type: none"> <li>1. Stop acid feed and flush column with water.</li> </ol>

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Table 6-1. Off Standard Conditions (Continued)

## Concentrator Section

Potential Conditions	Possible Causes	Suggested Corrective Actions
Radionuclides, Nitrates in BCP Stream	<ol style="list-style-type: none"> <li>1. Inadequate deentrainer water feed addition.</li> <li>2. Broken demister pad and/or improper spray and fogger patterns.</li> </ol>	<ol style="list-style-type: none"> <li>1. Provide required water feed to deentrainer.</li> <li>2. Reduce IX/concentrator feed rates until repaired.</li> </ol>
Solids in Low-Level Waste After Concentrating	<ol style="list-style-type: none"> <li>1. Precipitation of salts during concentration.</li> <li>2. Carry over from PHP filter.</li> </ol>	<ol style="list-style-type: none"> <li>1. If excessive solids are generated, dilution water may be required to assure pumpability. Consider concentrating to a lower spg or Na molarity.</li> <li>2. Causes and corrective actions as above for high dP across the PHP filter.</li> </ol>
Lag Storage Full before/ after E-20-2 Concentrator	<ol style="list-style-type: none"> <li>1. High Na level in Cs product.</li> <li>2. High volumes of water flush during a temperature and/or pressure excursion in IX column.</li> </ol>	<ol style="list-style-type: none"> <li>1. Neutralize to 0.1M OH<sup>-</sup> and then recycle. Assure 0.1M HNO<sub>3</sub> for next sodium scrub.</li> <li>2. Recycle to IX column feed lag storage.</li> </ol>

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Table 7-1. Process Vessels  
Working Volume  
L (gal)

Vessel

Purpose

Cell 7/8 Settle/Decant Routing

TK-8-1	Primary settling tank	15,520 (4,100)
TK-8-2	Lag storage of feed	15,520 (4,100)
TK-7-1	First wash settling tank	15,520 (4,100)
TK-7-2	Second wash settling tank	15,520 (4,100)
TK-6-1	Decant receiver/lag storage	15,520 (4,100)
TK-14-2	Decant lag storage	12,110 (3,200)
TK-13-1	Decant lag storage	11,850 (3,130)

Cell 9/30 Settle/Decant Routing

TK-9-2	Primary settling tank	15,519 (4,100)
TK-30-3	First wash settling tank	11,355 (3,000)
TK-30-2	Second wash settling tank	11,355 (3,000)

PHP Filter Operations

TK-29-2	Lag storage for PHP feed	12,468 (3,294)
TK-33-1	Lag storage for PHP feed	42,570 (11,246)
TK-37-2	DE precoat tank	12,415 (3,280)
TK-34-3	PHP feed tank	13,320 (3,520)
TK-34-2	PHP filtered solids receiver tank	13,320 (3,520)
TK-34-1	PHP filtrate receiver tank	13,320 (3,520)
TK-31-3	PHP filtered solids lag storage	9,840 (2,600)
TK-27-3	PHP filtered solids transfer	11,360 (3,000)

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Table 7-1. Process Vessels (continued)

<u>Vessel</u>	<u>Purpose</u>	<u>Working Volume</u> <u>L (gal)</u>
Plant Transfer Operations		
TK-11-2	Receipt of NCAW feed from AR Vault	11,850 (3,130)
TK-12-1	Flush water for AR vault line	12,870 (3,400)
TK-25-1	TRU Solids transfer to AR Vault	14,760 (3,900)
TK-25-2	Low level waste to tank farms	14,720 (3,890)
Ion Exchange/Concentrator Operations		
TK-17-1	IX feed lag storage	14,950 (3,950)
TK-17-2	IX feed lag storage	15,140 (4,000)
TK-18-3	IX feed tank	2,233 (590)
T-18-2	New IX column	9,350 (2,470)
TK-21-1	Nitric acid makeup/recycle tank	42,620 (11,260)
TK-18-1	IX waste receiver tank	5,600 (1,480)
TK-24-1	E-23-3 Feed tank	41,980 (11,090)
E-23-3	Waste concentrator	7,570 (2,000)
TK-23-1	Waste concentrator receiver tank	2,400 (634)
TK-19-1	IX Eluant receiver tank	42,620 (11,260)
E-20-2	Eluant concentrator	757 (200)
TK-20-1	Receiver tank for E-20-2	1,610 (425)
TK-37-3	Lag storage for cesium solution	12,420 (3,280)
TK-36-1	Long term cesium solution storage	12,110 (3,200)
TK-29-3	Lag storage for Low Level Waste	12,074 (3,190)
TK-32-1	Lag storage for Low Level Waste	12,020 (3,175)

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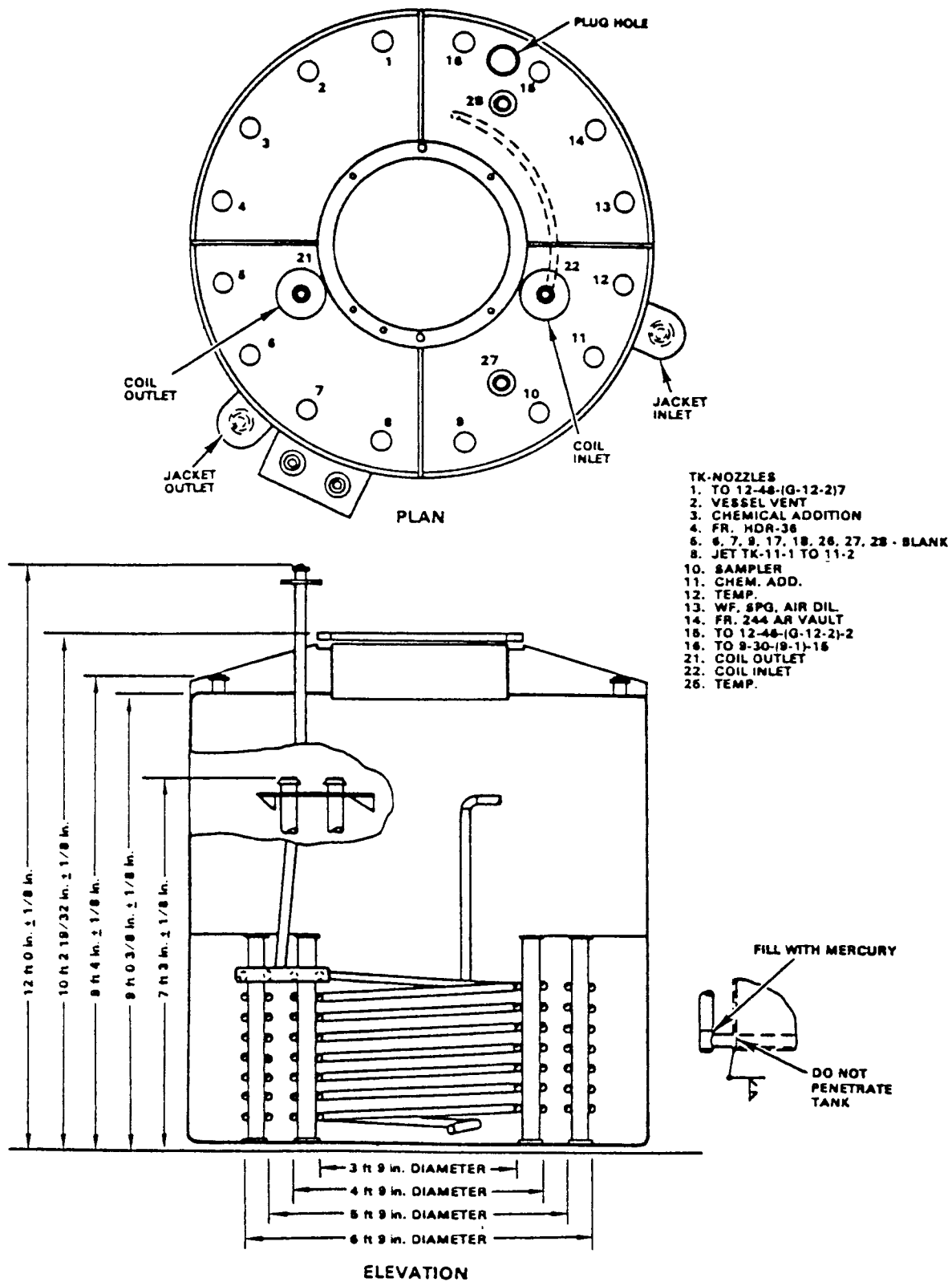
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Table 7-2. Scale Tanks

<u>Tank</u>	<u>Purpose</u>	<u>Capacity</u> <u>L (gal)</u>
TK-6A	Wash water, $\text{HNO}_3$ addition	1,510 (400)
TK-7A	Ferric nitrate, wash water addition	1,510 (400)
TK-8A	Ferric nitrate, wash water addition	1,510 (400)
TK-9A	Ferric nitrate, wash water addition	284 (75)
TK-11A	Wash water, $\text{HNO}_3$ addition	284 (75)
TK-17A	Wash water, $\text{HNO}_3$ , NaOH addition	1,510 (400)
TK-18A	$\text{HNO}_3$ addition	1,510 (400)
TK-20A	$\text{HNO}_3$ addition	1,510 (400)
TK-23A	NaOH, $\text{HNO}_3$ addition	1,510 (400)
TK-24A	NaOH, $\text{HNO}_3$ addition	1,510 (400)
TK-25A	NaOH, $\text{NaNO}_2$ addition	1,510 (400)
TK-29D	NaOH addition	284 (75)
TK-30A	Flush water, slurry water	1,510 (400)
TK-34A	Diatomaceous earth body addition, $\text{HNO}_3$ addition	1,510 (400)
TK-39A	Diatomaceous earth precoat addition	227 (60)

Figure 7-1. Typical Canyon Tank



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## 7.2 ROUTES AND JETS/PUMPS

All routes are shown on the flowsheet figures in the Appendices. All jet sizes are 75 gpm except for the decant jets which are 25 gpm.

The special jet dip leg referred to in Section 5.2, "Settle/Decant Process Control" is shown in Figure 7-2. It will have four dip legs of various heights incorporated to allow for the possibility of changing solids level in the NCAW feed.

## 7.3 AGITATORS

Agitation must be provided in those vessels which contain solids in solution. These include the tanks in which the settled and filtered solids resulting from NCAW pretreatment will be stored and transferred. The agitation prevents solids from settling and promotes homogeneous solution conditions for transfer operations. Data for these agitators are given in Table 7-3.

## 7.4 VESSEL VENT SYSTEMS

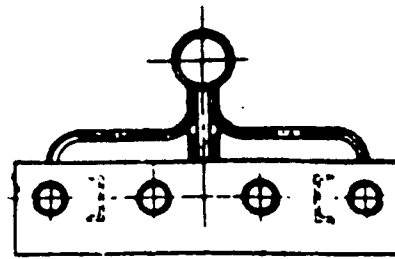
The primary function of the vessel vent system is to maintain the atmosphere of the canyon vessels at a vacuum with reference to the cell containing the vessel. The vessel vent systems associated with the process vessels form the primary containment and the vacuum with respect to the cell. This ensures preferential inleakage to the vessel rather than out leakage from the vessel during normal operation of the vessel vent systems.

There are two separate vent systems, and the equipment for both systems is located in Cell 22. The connections of these systems to the process vessels used in NCAW processing for the demonstration runs are shown in Table 7-4.

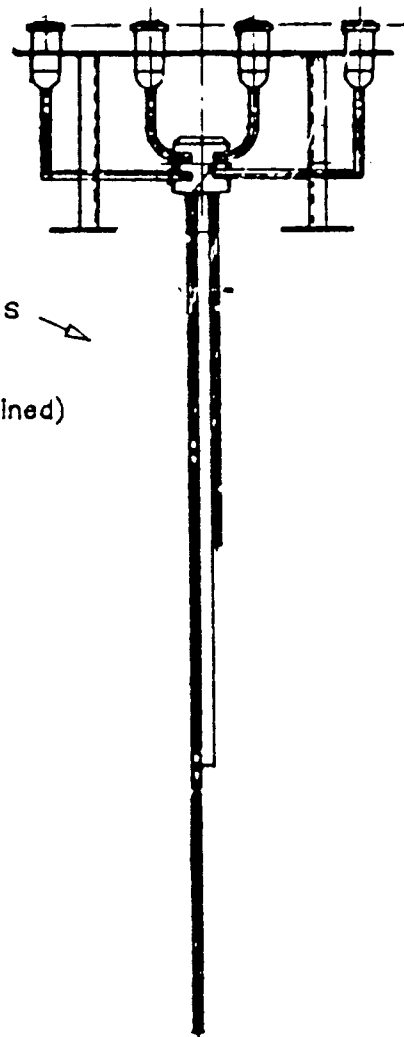
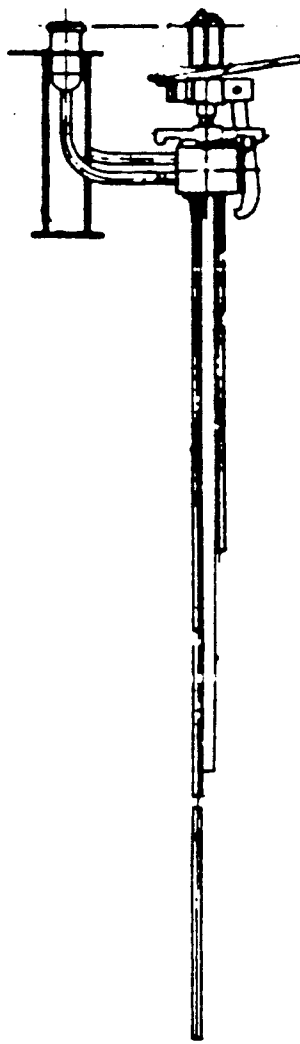
- o Vessel Vent No. 1: This system was designed to vent and filter the gases from those process vessels which do not contain ammonia.
- o Vessel Vent No. 2: This system was designed to vent, scrub, and filter gases from process vessels in which ammonia is present.

### 7.4.1 Vessel Vent System No. 1 (Reference 43)

The vessel vent equipment for the No. 1 system is composed of a steam heater (E-22-3), a high efficiency filter assembly (F-22-5), a steam or air-operated jet (J-22-4), a condenser (E-22-4), a condensate receiving tank, (TK-22-1), and a recycle drain pump (PA-22-1). Vent air from the process vessels enters the heater via Header 22 where it is heated above its saturation temperature before entering the F-22-5 filter assembly. The filtered gases discharge to the condenser. Condensible vapors are removed from the gas stream, and the non-condensibles are discharged to the air tunnel. Condensate is pumped to TK-24-1.



Flexible jumper may be connected  
to one of four dip legs



← Jet Dip Legs →  
Four lengths  
(To be determined)

Figure 7-2. Schematic of Multi-length Jet Dip Legs

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Table 7-3. Agitators

<u>Process Vessel</u>	<u>Agitator (hp)</u>
TK-11-2	A-11-2 (7.5)
TK-8-1	A-8-1 (5)
TK-8-2	A-8-2 (5)
TK-7-1	A-7-1 (7.5)
TK-7-2	A-7-2 (7.5)
TK-6-1	A-6-1 (7.5)
TK-14-2	A-14-2 (7.5)
TK-25-1	A-25-1 (7.5)
TK-9-2	A-9-2
TK-30-2	A-30-2 (7.5)
TK-30-3	A-30-3 (7.5)
TK-27-3	A-27-3 (5)
TK-34-2	A-34-2 (3)
TK-33-1	A-33-1-1, 2 (7.5, 7.5)
TK-34-3	A-34-3 (7.5)
TK-13-1	A-13-1 (5)
TK-29-2	A-29-2 (7.5)
TK-31-3	A-31-3 (7.5)
TK-37-2	A-37-2 (7.5)

Table 7-4. Vessel Vent System Connections

<u>Process Vessel</u>	<u>Vent System</u>
TK-11-1	VV#1
TK-11-2	VV#1
TK-8-2	VV#1
TK-8-1	VV#1
TK-7-1	VV#1
TK-7-2	VV#1
TK-14-1	VV#1
TK-25-1	VV#2
TK-13-1	VV#1
TK-29-2	VV#2
TK-25-2	VV#2
TK-30-3	VV#2
TK-30-2	VV#2
TK-31-1	VV#2
TK-31-3	VV#2
TK-9-2	VV#1
TK-27-3	VV#1
TK-33-1	VV#1
TK-29-3	VV#1
TK-36-1	VV#2
TK-34-3	VV#2
TK-34-2	VV#2
TK-34-1	VV#2
TK-17-1	VV#2
TK-17-2	VV#2
TK-18-3	VV#2
TK-19-1	VV#2
TK-21-1	VV#2
TK-20-1	VV#2
TK-37-3	VV#2
TK-18-1	VV#2
TK-24-1	VV#2
TK-23-1	VV#2

#### 7.4.2 Vessel Vent System No. 2 (Reference 44)

The vessel vent equipment for the No. 2 system is composed of an ammonia scrubber tower (T-22-2), a condensate receiving tank (TK-22-1), a recirculating drain pump (PA-22-1), a steam heater (E-22-7), a prefilter (F-22-6), four high efficiency filter assemblies (F-22-8-1), F-22-8-2, F-22-9-1, and F-22-9-2), and a steam or air operated jet (J-22-9). The condensate receiving tank and recirculating drain pump are common to both vent systems. Contaminated gases from vessels connected to vessel vent system #2 enter T-22-2 via Header 146. From T-22-2 the gases pass through the heater, prefilter, and the three filter assemblies. From the filters, the gases pass through a jet which discharges to the vapor space of the 24-in cooling water drain line.

The Vessel Vent 2 system originally handled a nominal vapor flow rate of approximately 200 ft<sup>3</sup>/min per day. However, modifications to cesium processing resulted in an increased demand upon the Vessel Vent 2 system. A flow rate of approximately 250 to 300 ft<sup>3</sup>/min is required.

### 7.5 CONCENTRATORS AND CONDENSERS

#### 7.5.1 Cesium Eluate Concentrator (E-20-2) and Condenser

The Cell 20 concentrator has one tube bundle containing 307 1-inch stainless steel tubes with an outside surface area of 1197 ft<sup>2</sup>. The process solution is on the inside and the steam is on the outside of the tubes.

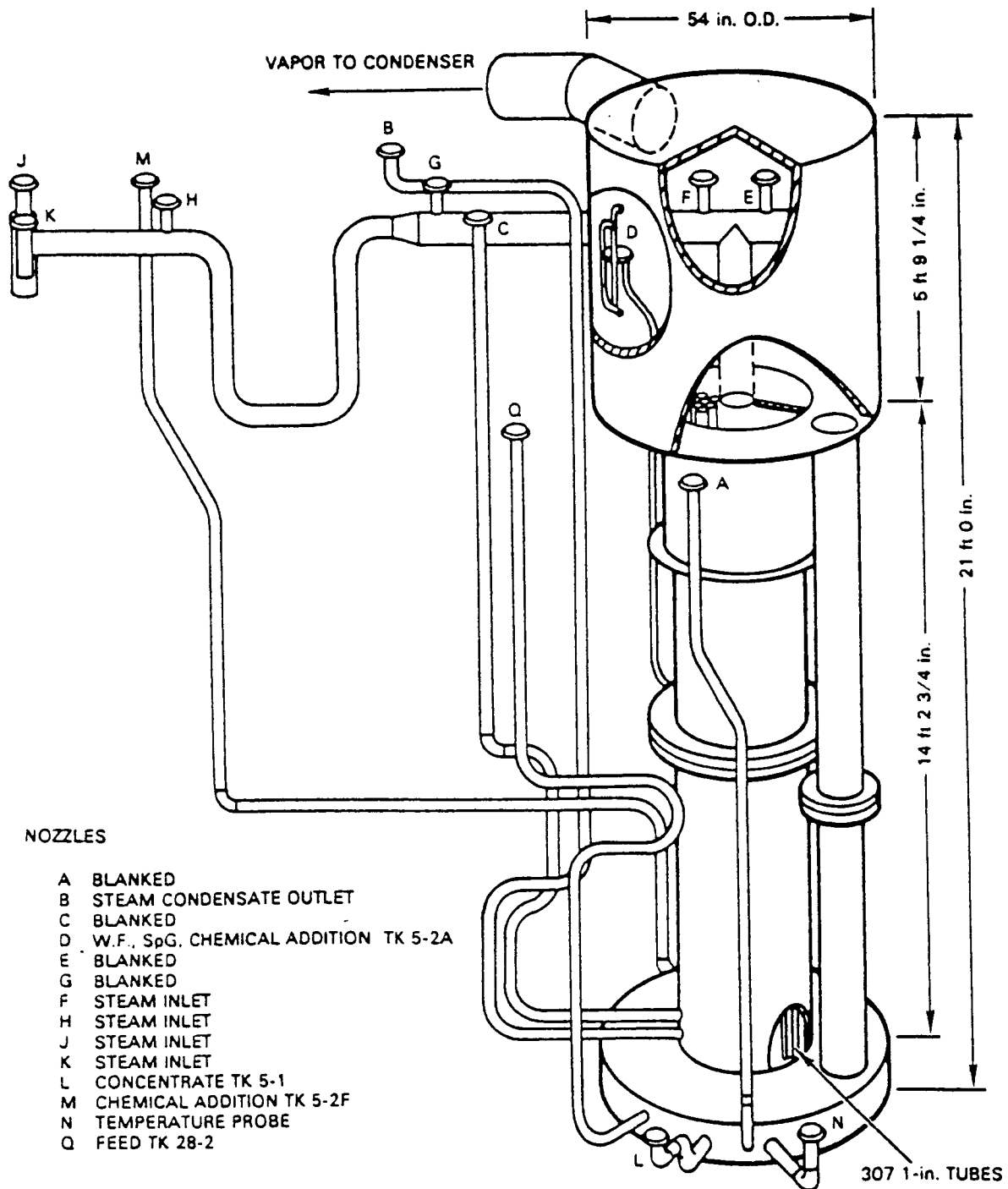
A reverse dished impingement plate is located in the upper shell which deflects the percolated liquid effecting a separation of liquid and vapor. An 8-inch downcomer connects the vapor section with the enlarged bottom section to allow recirculation of the concentrated liquid.

The deentrainment shell, directly above the vapor shell, contains a mist separator and spray nozzles. The mist separator consists of "Z" baffles which remove the entrained droplets of liquid from the vapors returning the liquid to the deentrainment section through a seal pot, which prevents vapors from bypassing the impingement plate and traveling directly to the mist separator.

Semicircular baffles, acting as tube bundle supports, prevent channeling of the steam through the tube bundle area. Expansion joints in both the evaporator shell and the downcomer minimize strain due to large temperature changes.

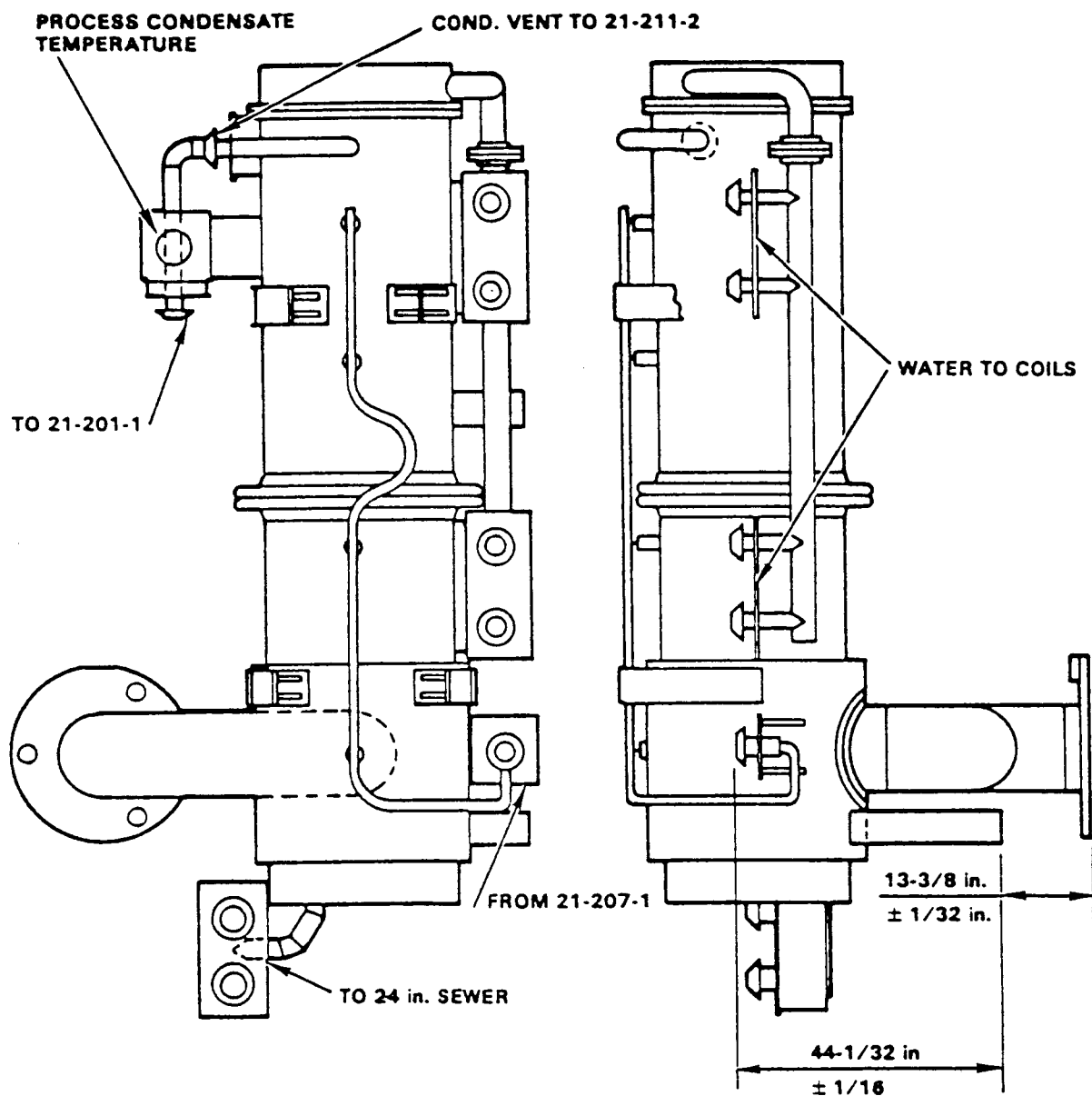
The horizontal, multipass, water-tube condenser located in Cell 20, has been modified and relocated from 221-U Building. Each condenser has 10-foot long tubes (342) with a surface area of 895 ft<sup>2</sup>, and there are nine tube passes. Seven segmental baffles spaced throughout the length of each condenser distribute the vapor flow through the shell. An expansion joint is provided in the condenser shell to relieve stresses caused by shell temperature changes. Condenser 20-3 is equipped with four water spray nozzles. A sketch of the concentrator is shown in Figure 7-3 and the condenser in Figure 7-4.

Figure 7-3. E-20-2 Concentrator



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Figure 7-4. E-20-3 Condenser



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### 7.5.2 Cell 23 Concentrator Assembly

The elevation view of the whole concentrator assembly is shown in Figure 7-5 and the plan view of the E-23-3 concentrator is shown in Figure 7-6.

- o Concentrator E-23-3: This 2,000 gallon capacity concentrator is a vertical, single-pass shell-tube, thermal-recirculated and steam heat evaporator. It has two removable stainless steel tube bundles located in 55-inch diameter and 14-foot-5-inch high cylinders. The west bundle has an inside area of 1,850 ft<sup>2</sup> and design heat duty of 27 million BTU/hour. The east bundle has an inside surface area of 1,290 ft<sup>2</sup> and design heat duty of 3 million BTU/hour.

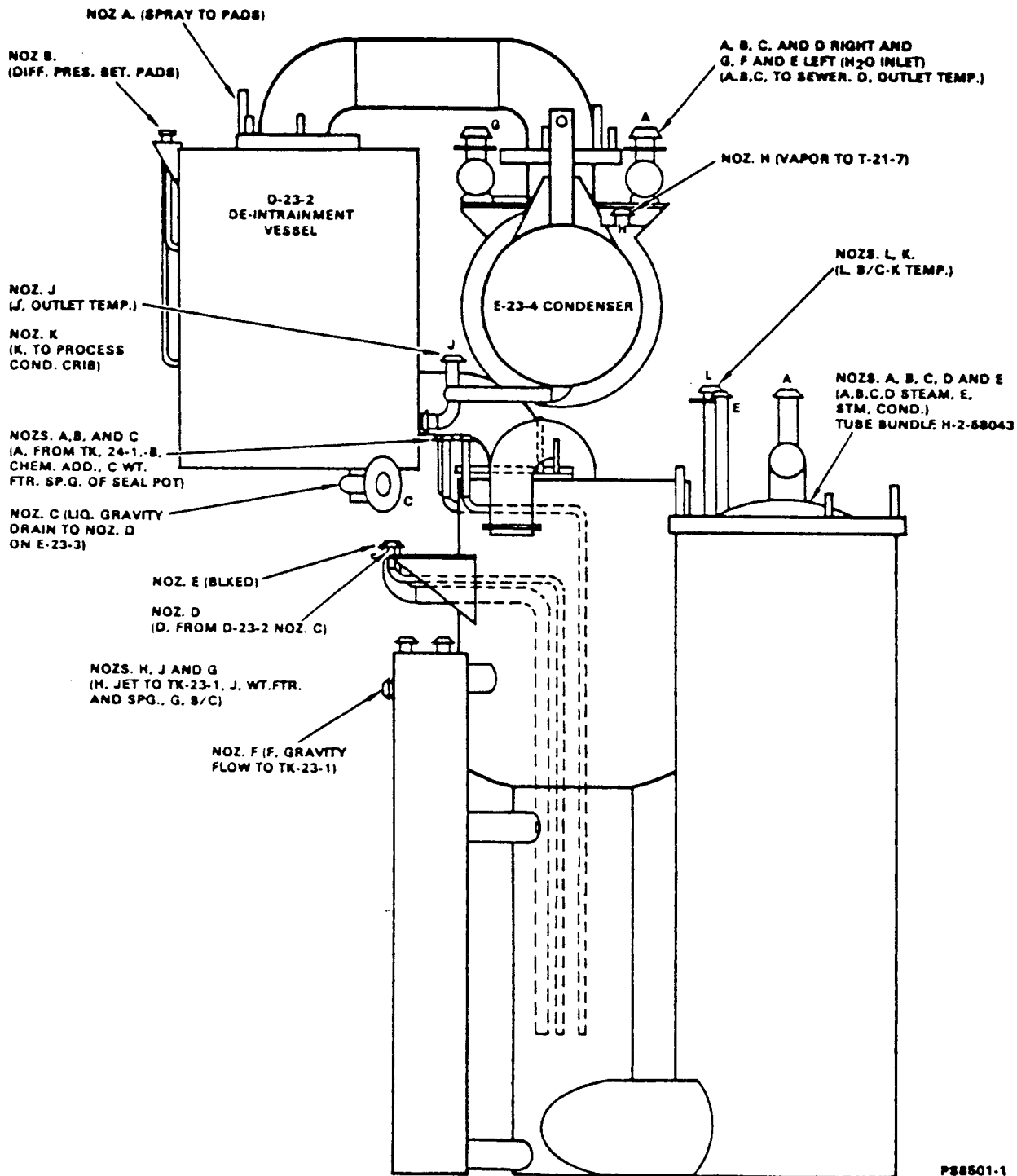
The 687 tubes in the west bundle are 1-1/2 inches in diameter, and the 630 tubes in the east bundle are 1 inch in diameter. Both bundles have four steam inlets and one steam condensate outlet on top, and they all have baffles in the shell to ensure that the shell-side fluid will flow across the tubes and thus induce higher heat transfer. During the periods of sensitive operation, the east bundle is used, since it is easier to control, especially at startup.

A 30-inch draft tower is situated between the tube bundles. The liquid, induced by boiling, circulates down the draft tower and back into the tube bundle sections. The overflow column, located next to the draft tower, contains the outlet for the concentrated solution to TK-23-1 as well as the weight factor and specific gravity dip tubes. The concentrator has a seal pot venting to the air tunnel. If the seal pot was allowed to become empty, the concentrator would lose vacuum, resulting in loss of operating efficiency.

- o Deentrainer D-23-2 and Condenser E-23-4: The vapors travel up through the D-23-2 deentrainment vessel to the E-23-4 condenser. The deentrainer consists of two demister pads approximately 6 inches thick with fogger nozzles between the pads. Demineralized water addition through the fogger nozzles is controlled for the operating gallery at the cell 23 Operator Interface Unit (OIU). The demineralized water is pressurized to 500 psig then heated to 210 degrees Fahrenheit before passing through the deentrainer fogger nozzles. The sprays through the fogger nozzles agglomerate (combine) entrained liquid droplets in the vapor passing through the first pad. This causes the agglomerated droplets to fall out of the vapor stream when they contact the second pad.

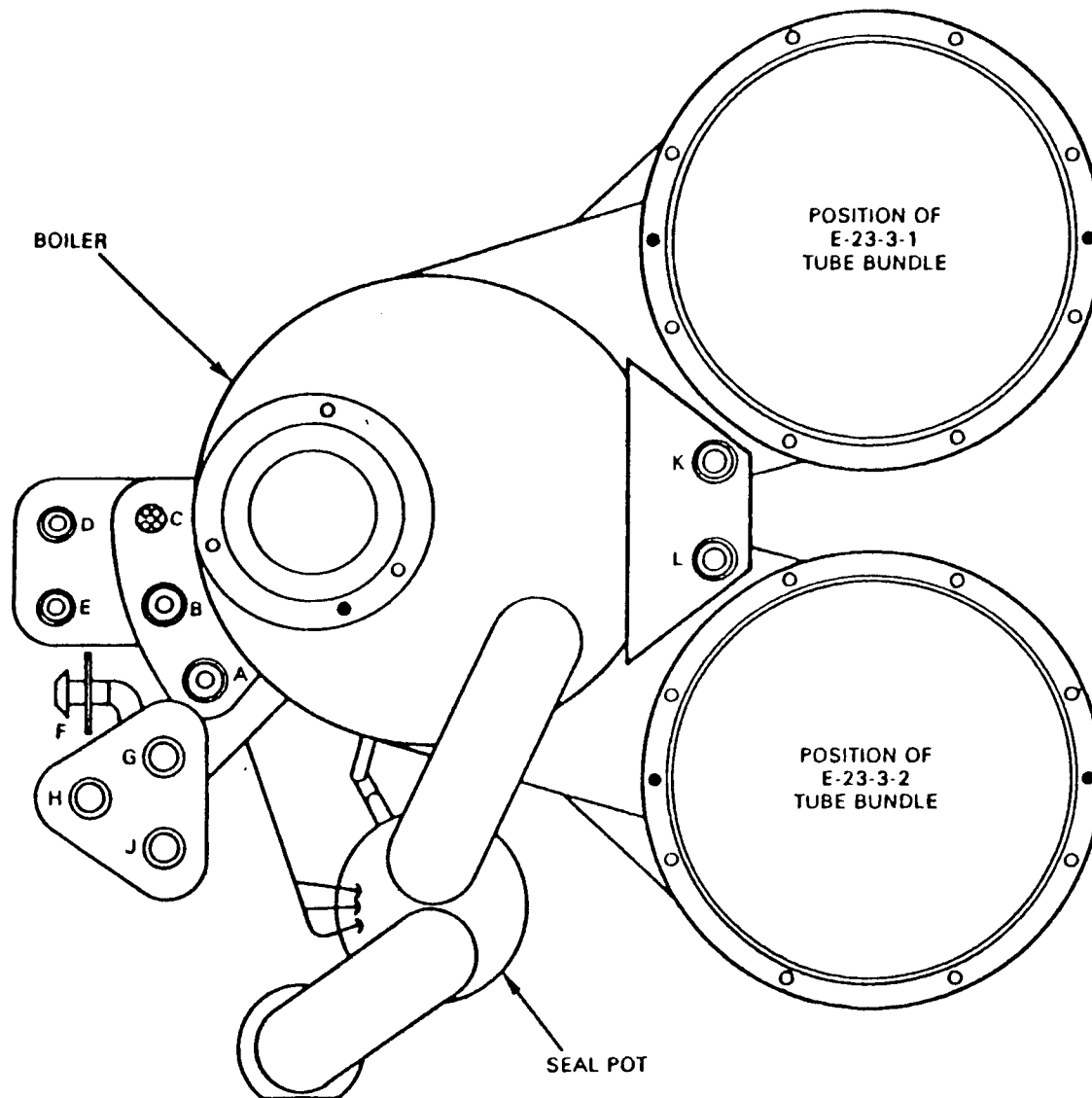
There are two deentrainer spray systems, both controlled from the cell 23 OIU, which operate in parallel so if one system becomes inoperable, the other system can be used. Each system (Figure 7-7) consists of a high pressure pump, a PRV to regulate the pressure to 400 psig, and a flowmeter on the pipe gallery side of cell 23. On the canyon side there are two fogger nozzles which also operate in parallel inside the deentrainer between the two demister pads. One 225 kWatt heater services both systems to heat the demineralized water.

Figure 7-5. Waste Concentrator Assembly E-23-3



P88501-1

Figure 7-6. Plan View (E-23-3) Concentrator Assembly



- A - 28-FR. 24/53 VIA 164 HEADER
- B - 25-CHEMICAL ADDITIVE
- C - 23-WF, SPG. AND H<sub>2</sub>O ADDITIVE
- D - GRAVITY DRAIN FR. D-23-2
- E, G, L - BLANK
- F - GRAVITY FLOW VIA 169 HEADER TO TK-23-1
- H - 31-JET TO TK-23-1
- J - 216-WF, SPG.
- K - 227-TEMPERATURE

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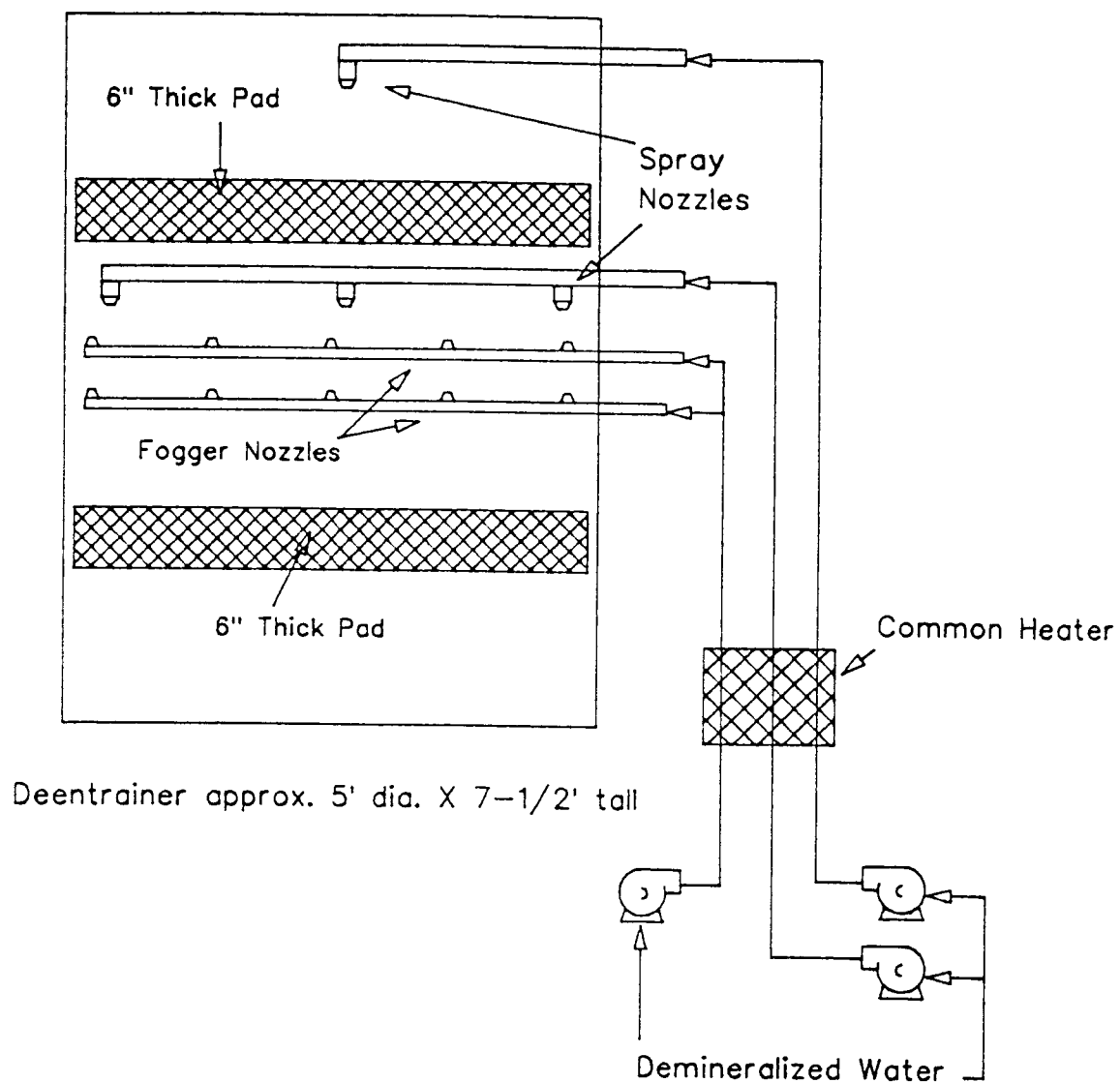


Figure 7-7. Schematic of Deentrainer System

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The condensate from the condenser is then routed to the BCP (B Plant Process Condensate) tank in 221-BB. The condenser, 38-inches in diameter and 10 feet in length, is situated horizontally above the concentrator. It is water cooled and has a coil surface area of 1,340 ft<sup>2</sup> and heat duty of 50 million BTU/hr.

#### 7.6 CELL 18, NEW ION EXCHANGE COLUMN

The current ion exchange column, T-18-2, is not designed for the use of nitric acid eluant with an organic ion exchange resin. Therefore, a new ion exchange column is being designed. The preliminary design for the new column is shown in Figure 7-8 (Reference 45). The new column has similar dimensions as the current Cell 18 column: six foot diameter, approximately 15 feet high, with a 330 cubic foot resin capacity. The primary differences between the current and new column is the installation of safety features consisting of a rupture disk and additional instrumentation and interlocks. Figure 7-9 shows the design for both the instrumentation and interlocks associated with the new column and the new nitric acid dilution system.

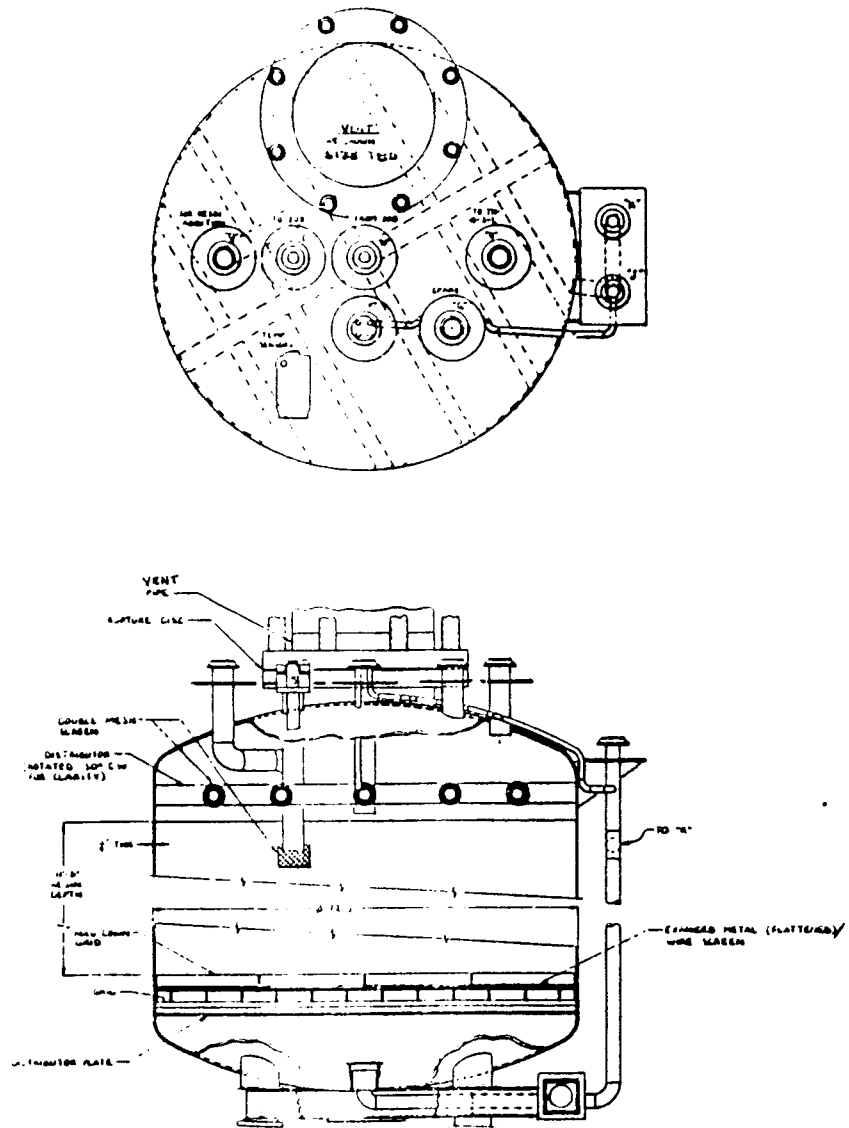
The new ion exchange column design includes the installation of a rupture disk to prevent catastrophic column failure should a resin/acid reaction occur. The rupture disk relieves reaction gases and resulting steam at a relatively low pressure, preventing a large energy accumulation within the column. The diameter of the rupture disk will be sized to allow for two phase flow (liquid and gas) venting. Additional instrumentation and interlocks will be provided to prevent acid addition during a resin/acid reaction. The number of temperature probes will be increased to three and are interlocked with the column feed pump and an alarm. The column pressure sensors are interlocked to the column feed pump, the high pressure alarm and the column vent valve, to prevent premature rupture disk failure in the event of minor pressure excursion.

Considered in the preliminary design of the new column was the use of cooling water. A water cooling jacket was considered, but HEATING 5 computer code calculations indicated that the jacket would be ineffective. Even with a column design diameter of only three feet, water jacket cooling was found to be ineffective because of the low resin thermal conductivity (References 45 and 46).

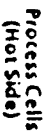
For down-flow operation, solutions enter the column at the top through a star pipe system similar to the one in the current column. However, this system will also be supported by the column walls to help prevent premature failure. These pipes will be wrapped with mesh screen to prevent resin from escaping during up flow operations. The lower portion of the column is filled with ion exchange resin which is added to the column as a slurry through a nozzle on the top of the column. The resin is supported by a expanded metal (flattened)/wire screen which in turn is supported by a grating-type grid which is supported by a distributor plate. The ion exchange resin may be removed by lowering a steam jet into the column through a top nozzle.

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Figure 7-8. Cell 18, New Ion Exchange Column



# NCAW Cesium Ion Exchange Preliminary Design



1. THE CONCENTRATION OF ACID IN THE COLUMN IS USED TO DETERMINE THE CONCENTRATION OF THE SODIUM SULFATE ACID CONCENTRATION IS TOO HIGH THE "PUMP WITH O.C." WILL NOT ALLOW CONCENTRATION TO INCREASE.
2. THE CONCENTRATION OF ACID IN THE COLUMN IS USED TO DETERMINE THE FINAL ACID DILUTION. IF THE CONCENTRATION IS TOO HIGH THE "CONCENTRITY WITH O.C." WILL NOT ALLOW CONCENTRATION TO INCREASE.
3. IF THE COLUMN CONCENTRATION IS TOO HIGH AS DETERMINED BY THE CONCENTRATION POINT, OR THE COLUMN PRESSURE AND OR TEMPERATURE FIELD A SPECIFIC VALVE, THE FIELD PUMP IS CUT OFF.
4. IF THE COLUMN PRESSURE EXCEEDS A PRESET VALUE, THE FIELD VALVE IS OPENED. THE PRESSURE IN THE COLUMN DOES NOT CONTINUE TO INCREASE BECAUSE THE FIELD PUMP IS STOPPED.
5. IF THE COLUMN PRESSURE IS TOO CONCENTRATED, THE PUMP WILL NOT OPERATE.

## 7.7 BAILEY PROCESS CONTROL SYSTEM

Automatic process control is provided through a Bailey Controls Company "NETWORK 90" controller and data acquisition system. The network supports Process Control Units (PCU), Operator Interface Units (OIU), or Computer Interface. The NETWORK 90 system optimizes plant efficiency by maintaining close supervision of the plant processes. The system collects data on such process variables as flow rate, temperature, pressure, and levels, and regulates these process variables in accordance with an overall control strategy. The NETWORK 90 system centralizes all key parameters, which are process variables and other quantities used to implement the control strategy, and presents this information for supervision via the Operator Interface (OIU) CRT monitor.

Data collection and automatic control of the process is performed by the Process Control Unit (PCU). This unit is connected directly to the process loops and data acquisition points under its control through I/O field wiring and for this reason is usually located close to the process. The PCU contains a number of different modules individually configured to perform data acquisition and/or specific control functions.

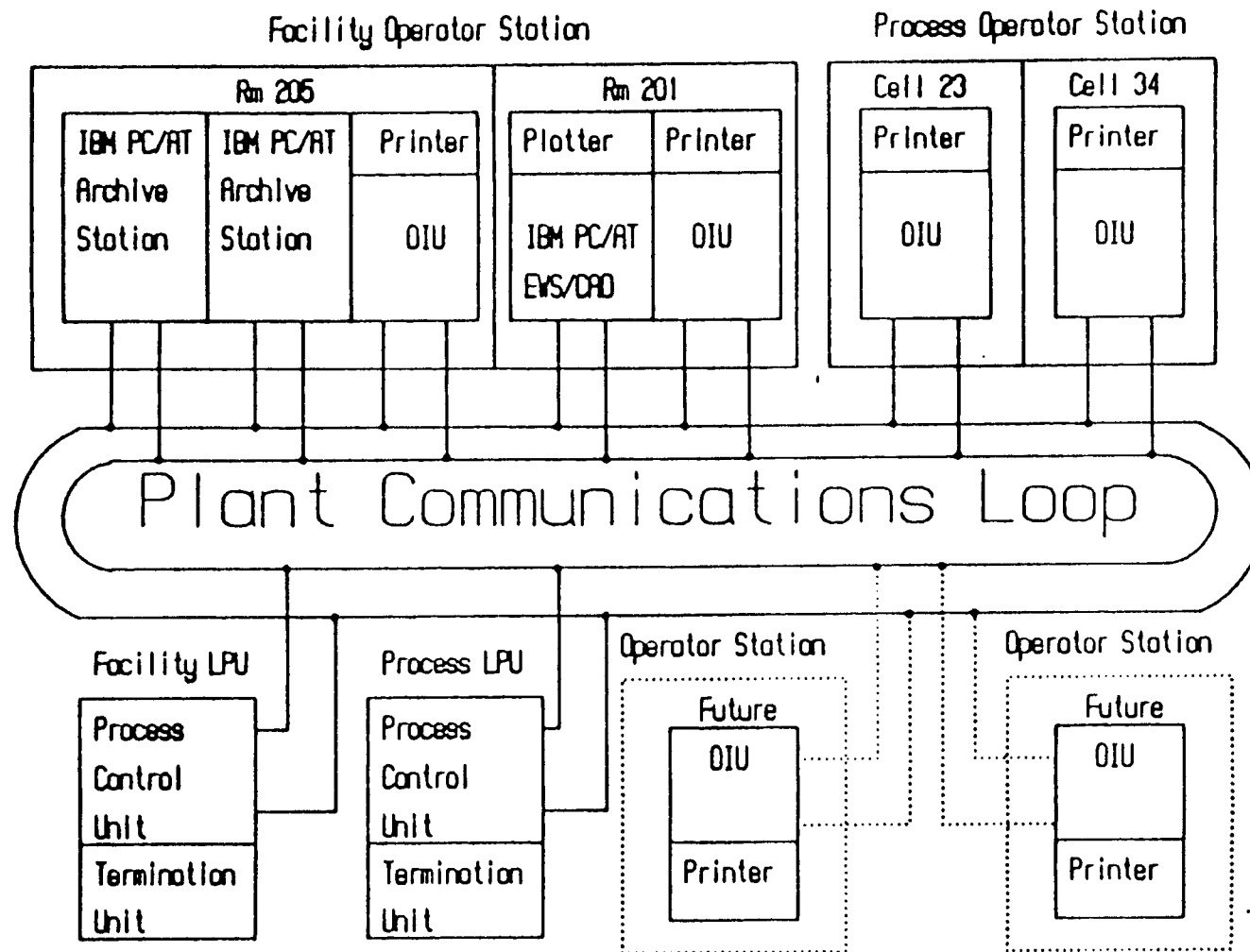
All the PCUs within the system are connected to each other through the plant communication loop (PCL). This enables the data acquisition or loop control performed by one PCU to be used by another PCU. The point of unit connection to the plant loop is called a node. A data message sent by a PCU is relayed along the PCL from one node to the next node until the message reaches its destination. Operator supervision and manual control of plant processes is performed through the OIU which is also connected to the PCL. The system includes a computer interface unit which connects three process computers to the PCL.

The Bailey Process Control System is being installed in seven different phases (Reference 47). Phase I consists of the NETWORK 90 system as shown in Figure 7-10 with the exception of the archive stations in room 205 and the future OIUs. It consists of the following:

- o OIUs with printers. Three of these are available, one in room 205 and two in the operating gallery at cells 23, and 34.
- o Local Processing Units (LPUs) that contain the programmable controllers, slave modules, and the other components that interface with the Facility status, Process monitoring, and control field instruments. LPUs include a PCU and a Termination Cabinet.
- o An engineering work station for use by process engineering for configuration design, document preparation, performance monitoring and system troubleshooting. This station is located in room 201 and will include an OIU, and IBM PC/AT plus a plotter and printer.
- o A redundant plant communications loop will provide back-up to the communications loop.

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Figure 7-10. Bailey Controls Company Network 90 System



o An un-interruptible power supply is located in the electrical gallery.

Phase II consists of Project B-557. This project, B Plant ventilation control system upgrade includes the HVAC instrumentation. Phase III consists of the archive stations located in room 205 which will be used for data storage. Phase IV, project B-499, B Plant liquid effluent measurement system upgrade, includes monitoring instrumentation. Phase V includes the instrumentation upgrades for the dispatchers' office. Phase VI includes the instrumentation upgrades for cell 23, Waste Concentrator area. Phase VII includes the instrumentation upgrades for Cell 34, PHP Filter area. All instrumentation in the Waste Concentrator and PHP Filter areas will be interfaced except for the jet gang valves.

Phases I, III, and VI are complete, while Phases II, IV, V, and VII are scheduled for completion in FY 88.

All interlock control in the areas involved in Phases I through VII discussed above will be done on the computer by the Bailey Process Control System through a series of control commands. This includes high level alarms, low level alarms, and pump and agitator on/off switches. Also, any OSR instruments such as air dilution flow meters, and temperature and pressure indicators will be done in the same way.

## 8.0 SAFETY

### 8.1 SOLUTION TRANSFERS

The accidental misrouting of process solutions will be prevented through administrative and physical controls. The use of blanked lines or lockouts on valves is the preferred method to give positive control against inadvertent misroutings, with administrative controls to be used where the physical controls cannot be applied.

### 8.2 ADDITION OF CAUSTIC

The reaction during caustic addition generates both heat and gases. As the amount of caustic addition to meet tank farm corrosion specifications is small, however, no excessive heat buildup or gas generation rates are expected. The rate of caustic addition to the first cycle cesium eluate must be controlled to prevent excessive temperature increases or gas generation rates.

### 8.3 CHEMICAL ADDITIONS

The essential materials used in the NCAW pretreatment process are diatomaceous earth, ferric nitrate,  $\text{HNO}_3$ ,  $\text{NaOH}$ , and  $\text{NaNO}_2$ . Each of these materials has inherent chemical toxicity and handling hazards. Safe handling practices and procedures in the event of an accident or spill are defined in the operating procedures.

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## 8.4 CRITICALITY

The B Plant Safety Analysis Report addendum (draft) for NCAW processing discusses the criticality hazards for this process. A designation of 271-B (B Plant) as a Limited Control Facility was issued by Criticality Engineering and Analysis (Reference 48) for the process test only.

The limited amounts of plutonium in NCAW should preclude most criticality concerns, but good process practices should be followed to minimize the potential for accidents. Agitation of the solids stream process vessels (with the exception of the settling cycles) is important to prevent solids from settling and potential accumulations. Effective tank and line flushes are required, with close attention paid to tank calibrations and solution volume to detect any solids buildup.

## 8.5 NITRIC ACID - ORGANIC RESIN REACTION

As discussed in Section 4.3.5, the introduction of concentrated (above 1 molar) nitric acid into the ion exchange column could generate excessive heat through an oxidation reaction that accelerates with temperature. The effect could result in gas generation, steam formation, and a pressure buildup. To prevent this, the new acid dilution system will provide for diluting the 12 M nitric acid source to 1 M outside of B Plant and then further diluted inside the building to the less than 1 M concentrations needed in the ion exchange process. Furthermore, specific gravity indicators, conductivity meters, and interlocks on pumps are included in the process design. An Operational Safety Requirement to assure that concentrated nitric acid does not enter the ion exchange column is recommended.

The recent nitric acid/resin reaction tests (Reference 33) determined that the Duolite CS 100 resin is most reactive to acid when the resin is in the as-received hydrogen form. This emphasizes that dilute acid should never be added to the column until normally scheduled in the process sequence. It is important to operate the column through the normal process cycles: the two steps of regeneration with sodium hydroxide, followed by the regeneration water flush, the NCAW supernate feed, the water flush, then the sodium scrub with 0.1 M nitric acid, then elution (0.3 M nitric acid), and finally water flush.

Controls on the potential recycle of the acidic cesium eluate to the ion exchange column will be put in place including engineering controls (specific gravity or conductivity interlocks), and administrative controls (sampling).

## 8.6 WATER FLUSHES TO PREVENT ACID-BASE REACTIONS

The water flushes specified in the normal IX process cycles are of different amounts of column volumes (Table 4-11). The feed and elution flushes require the largest volumes in order to prevent subsequent reactions of basic and acidic streams, preventing heat and gas generation. All specified water flushes to the IX column are important and must always be conducted, using at least as many column volumes as specified.

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## 8.7 HAZARDOUS WASTE ISSUES

A chemical waste management system has been developed based on the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Washington Department of Ecology (WDOE) regulations. Further development of this system is currently in progress, to address issues relating to the recent byproducts ruling. An Effluent Monitoring Plan for B Plant will cover hazardous waste issues in detail. No new hazardous waste streams are expected from the NCAW pretreatment process.

Existing procedures and equipment will control gaseous and radioactive emissions and should be adequate. Demonstration processing will establish if further measures are needed.

The various essential materials used in NCAW processing and their respective CERCLA and WDOE release limits are shown in Table 8-1. Operating procedures will ensure safe handling of all essential materials and contingency plans will be developed to deal with accidents or spills.

## 9.0 ESSENTIAL MATERIALS

### 9.1 FERRIC NITRATE ( $\text{Fe}(\text{NO}_3)_3$ )

Form: The ferric nitrate is received in bagged form as a dry powder, and must be made up in a scale tank to the desired concentration. The solid is usually in the form of a nanohydrate,  $\text{Fe}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$ .

Use: Ferric nitrate is used as a flocculating agent to increase the settling rate of the NCAW solids and to obtain a clearer supernate in a shorter time.

Amount Required: 3.7 kg (8.1 lb) per batch at 200 ppm addition.

### 9.2 DIATOMACEOUS EARTH

Form: Diatomaceous Earth is received in bagged form as a dry powder. Precoat and body feed additions must be made up in scale tanks.

Use: Diatomaceous Earth is used as a filter aid in the PHP filter. It is used both as a precoat media on the filter surface and mixed with the feed (body feed) to promote porous solids cake formation and long filter loading cycles.

Amount: 2.0 kg (4.4 lb) per precoat batch, and 2.9 kg (6.4 lb) per batch of body feed.

### 9.3 SODIUM NITRITE ( $\text{NaNO}_2$ )

Form: Received as a powder in bagged form, to be made up in aqueous makeup area to needed concentrations.

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Table 8-1. Hazardous Waste Reportable Quantities (RQ)

Substance	CERCLA RQ*	WDOE RQ**	Minimum Accountable Quantity (MAQ)
Ferric Nitrate	1,000 pounds	400 pounds	o All quantities, when substance is in undiluted form o If in solution, all quantities in a concentration of or exceeding 1.0 wt%
Sodium Nitrite	100 pounds	400 pounds	o All quantities, when substance is in undiluted form o If in solution, all quantities in a concentration of or exceeding 0.1 wt%
Sodium Hydroxide	1,000 pounds	400 pounds	o If in solution, all quantities in a concentration of or exceeding 1.0 wt% o If in solution, all quantities with a pH equal to or greater than 12.5
Nitric Acid	1,000 pounds	400 pounds	o If in solution, all quantities in a concentration of or exceeding 1.0 wt% o If in solution, all quantities with a pH equal to or less than 2.0
Diatomaceous Earth, Duolite Cs 100 IX Resin	Neither of these materials are considered hazardous chemicals and therefore are not regulated.		

\*CERCLA RQ is the total pounds of the pure chemical product, not of the solution

\*\*ECOLOGY RQ is for the total pounds of the solution

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Use: Added to the TRU solids stream to meet tank farm corrosion prevention specifications.

Amount: 0.85 M in a 380 L (100 gal) batch

#### 9.4 SODIUM HYDROXIDE (NaOH)

Form: Received in tank car lots at 19 M concentration.

Use: Added if required to the TRU solids stream to meet tank farm corrosion prevention specifications. Used as the regeneration solution for the ion exchange column and to neutralize the first IX cycle cesium concentrate and the sodium scrub.

Amount: 0.48 M in a 380 L (100 gal) batch) added to TRU solids stream to meet corrosion specifications. For regeneration:

First Cycle: First stage - 0.5 M, 6,600 L/batch (1,750 gal/batch)  
Second stage - 2.0 M, 13,250 L/batch (3,500 gal/batch)

Second Cycle: First stage - 0.5 M, 6,600 L/batch (1,750 gal/batch)  
Second stage - 2.0 M, 13,250 L/batch (3,500 gal/batch)

For sodium scrub neutralization:

First Cycle: 19 M, 310 L/batch (80 gal/batch)

Second Cycle: 19 M, 380 L/batch (100 gal/batch)

For cesium concentrate neutralization: 8.8 M, 380 L/batch (100gal/batch).

#### 9.5 NITRIC ACID (HNO<sub>3</sub>)

Form: Received in tank truck loads at 12.2 M concentration.

Use: Nitric acid is used as the sodium scrub and cesium eluent in the ion exchange process.

Amount: For the sodium scrub,

First Cycle: 0.1 M, 56,300 L/batch (14,900 gal/batch)

Second Cycle: 0.1 M, 36,400 L/batch (9,600 gal/batch)

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For the cesium eluent,

First Cycle: 0.3 M, 53,000 L/batch (14,000 gal/batch)

Second Cycle: 0.5 M, 39,700 L/batch (10,500 gal/batch)

#### 9.6 CESIUM ION EXCHANGE RESIN

Form: Duolite CS-100 is received in the hydrogen loaded condition in 55 gal drums, normally wet (40-60% moisture).

Use: The ion exchange resin is loaded into the T-18-2 column for use in the cesium ion exchange process.

Amount: A normal column volume, in the sodium form (expanded) condition, is 9,270 L (2,450 gal) of resin. The resin life is not yet determined, but a column volume loading is expected to last through the processing of one tank of NCAW based on past IX processing experience.

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## 10.0 REFERENCES

1. Gibson, MW and Landeene, BC, SD-RE-TI-190, Rev. 0, Flowsheet Computer Simulation for Demonstration of NCAW Pretreatment at B Plant, (September 1987)
2. Shaver, RL, Quarterly Tank Farm Waste Volume Projection, Third Quarter of FY 1987, SD-WM-ER-029, Rev. 6, Rockwell Hanford Operations, Richland, Washington, (July 1986)
3. Bratzel, DR/Buchanan, BR to Shah, KR, Letter 65453-84-204, NCAW Feed Pretreatment Laboratory Studies, August 24, 1984
4. Robertson, WA to Gibson, MW, Letter 65610-85-227, NCAW Sludge Washing Studies: Analysis of Laboratory Data, August 7, 1985
5. Lawler, JH, Demonstration Phase Neutralized Current Acid Waste (NCAW) Retrieval Flowsheet, PFD-T-200-00006, Rev. A-0, Rockwell Hanford Operations, Richland, Washington, (May 1985)
6. Sasaki, LM to DiLiberto, AJ, Letter 65611-86-039, "101-AZ NCAW Analysis Evaluation, April 8, 1986
7. Sasaki, LM To Gibson, MW, Letter 65611-86-151, Transuranics, Strontium- 90, and Ruthenium/Rhodium-106 in NCAW, August 25, 1986
8. Sasaki, LM to Landeene, BC, DSI, Ruthenium Content of NCAW, July 14, 1987
9. Castle, LL to Gibson, MW, Letter 65610-86-DRAFT, Time Cycles for NCAW Settling/Decant Operations, (July 1986)
10. Kimura, ML and Simmons, FM, SD-WM-PTR-007, Rev. 0, WESF Pneumatic Hyropulse Filter Process Test Report, April 18, 1987
11. Bullough, BD, Centrifugation and Inertial Filtration of NCAW, SD-WM-TRP-021, Rev 0, Rockwell Hanford Operations, Richland, Washington, (March 1986)
12. Gibson, MW, Centrifuge Scaleup Tests, SD-WM-TI-235, Rev 0, Rockwell Hanford Operations, Richland, Washington (April 1986)
13. Larson, DE, Elmore, MR, and McCarthy D, Incoming Letter 30538, Letter Report - Review and Scoping Evaluation of NCAW Pretreatment Processes, April 16, 1986
14. Gerboth, DM To Gibson, MW, Letter 65455-85-125, HGMF Work Completed in FY85 on NCAW Feeds, October 17, 1985
15. Gerboth, DM to Appel, JN, Letter 65455-86-010, Progress Report on High Gradient Magnetic Filter (HGMF) Studies in Support of NCAW Processing, January 29, 1986

# REFERENCES (continued)

16. Gerboth, DM, SD-WM-PTR-006, Rev. 0, B Plant NCAW Process Test Report, May 14, 1987
17. Motyka, T, Technical Data Summary for In-Tank Sludge Processing, DPSTD-84-100, E I du Pont de Nemours and Company, Savannah River Plant, Georgia (April 1984)
18. Gerboth, DM to Distribution, Letter 65455-86-012, Results of NCAW Settling/Decant Scoping Tests, February 11, 1986
19. Bullough, BD, NCAW Solids/Liquid Separation:Sedimentation, SD-WM-TRP-024, Rev 0, Rockwell Hanford Operations, Richland, Washington (DRAFT)
20. Bullough, BD to Gibson, MW, Letter 65455-86-069, Evaluation of NCAW Solids Settling Aids, July 1, 1986
21. Gibson, MW to Appel, JN, Letter 65610-85-313, Effect of Precoat Filtration on NCAW Glass Costs, November 21, 1985
22. Gerboth, DM, Results of Scoping Studies on Inverted Pneumatic Hydropulse (I-PHP) Filtration for PUREX NCAW Processing, SD-WM-TRP-022, Rev 0, Rockwell Hanford Operations, Richland, Washington (April 1986)
23. Bergman, DW, SD-WM-TRP-025, Results of the Inverted Pneumatic Hydropulse Filtration Tests, Rockwell Hanford Operations, Richland, Washington (April 1986)
24. Sasaki, LM, Tank Farm Flowsheet for Pretreated NCAW Transfer and Storage, PFD-T-033-00001, Rev. A-0, Rockwell Hanford Operations, Richland, Washington, (October 1986)
25. Bullough, BD to Sasaki, LM, Letter 65455-86-072, Effect of Diatomaceous Earth and Polyelectrolyte on NCAW Solids, July 2, 1986
26. Landeene, BC, SD-RE-TI-166, Rev. 0, NCAW Pretreatment - Comparison of Eluants for Ion Exchange, February 10, 1987
27. Gallagher, SA to Gibson, MW, Letter 65453-86-088, Report of Current NCAW Ion Exchange Laboratory Data, June 20, 1986.
28. Gibson, MW, and Landeene, BC, PFD-B-033-00001, Rev. A-0, Process Flowsheet Demonstration of Neutralized Current Acid Waste Pretreatment at B Plant, (September 1986)
29. Gallagher, SA, SD-RE-TD-001, Rev. 0, Cesium Ion Exchange Column Tests Using Pre 1982 and Post 1982 Duolite CS 100 Resin, June 22, 1987
30. Landeene, BC to Appel, JN, and Barton, WB, Letter 65610-87-055, Additional Cesium Ion Exchange Laboratory Tests, May 15, 1987

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# REFERENCES (continued)

31. Landeene, BC to Gallagher, SA, Letter 65610-87-133, Updated Ion Exchange Synthetic Feed Recipe, (September 30, 1987)
32. Bibler, JP to Landeene, BC, Resorcinol/Formaldehyde Resin Being Developed at Savannah River Laboratory, Control #8701379, E I du Pont Nemours and Company, Savannah River Laboratory, Georgia, March 11, 1987
33. Gallagher, SA, to Gale, LA, Letter, 65453-87-040, NCAW Ion Exchange Nitric Acid/Duolite CS 100 Resin Tests, March 23, 1987
34. Gallagher, SA To Landeene, BC, Letter 65453-86-105, Results of Differential Thermal Analysis on Duolite CS100 Resin, August 21, 1986
35. Grelecki, C to Gale, LA, HRC Project 6411, Hazards Research Corporation, Rockaway, New Jersey, July 16, 1987
36. Bratzel, DR to Slougher, JP, Letter 65453-86-101, Weekly Highlights for Week Ending August 5, 1986, dated August 5, 1987
37. Flesher, DJ, SD-WM-TPP-034, Rev 0, Technical Program Plan: Process Control for NCAW Demonstration at B Plant, (August 1987)
38. Zimmer, JJ, OSD-B-257-00047, Rev. A-0, NCAW Demonstration Processing Product Specifications, February 27, 1987
39. Kirch, NW, Technical Basis for Waste Tank Corrosion Specifications, SD-WM-TI-150, Rev. 0, (August 1984)
40. Bendixsen, RB and Winters, WI, SD-WM-DTP-023, Rev. 0, Analytical Development Plan for Pretreatment of NCAW at B Plant, (August 1987)
41. Buckingham, JS, Waste Management Technical Manual, ISO-100 (Unclassified), Isochem, Inc., Richland, Washington (August 1967)
42. Sewell, RG, B Plant Safety Analysis Report, SD-WM-SAR-013, Rev. 0, July 1985
43. Johnson, ME, B Plant Vessel Vent 1 System Flowsheet, PFD-B-060-00002, Rev. A-0, Rockwell Hanford Operations, Richland, Washington (July 1983)
44. Johnson, ME, B Plant Vessel Vent 2 System Flowsheet, PFD-B-060-00001, Rev. A-0, Rockwell Hanford Operations, Richland, Washington (November 1982)
45. Gale, LA, SD-WM-TI-311, Preliminary Design of the Cell 18 Cesium/Nitric Acid Ion Exchange System, July 31, 1987

## REFERENCES (Continued)

46. Gale, LA to Poling, WE, Letter 65920-87-041, Cooling Requirements for the Cell 18 Ion Exchange Column, April 7, 1987
47. Simmons, FM to Jacobsen, DR, Letter 65920-87-063, Phase Definition and Scope of the B Plant Instrumentation Upgrades Readiness Review, June 4, 1987
48. Doto, PC to Hibbard, RL, Letter 12721-86-023, Designation of 221-B Building as a Limited Control Facility for the Processing of NCAW Waste, March 24, 1986

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## 11.0 FLOW DIAGRAMS AND MATERIAL BALANCE

Schematics of the flowsheet routings and vessels associated with the B Plant Demonstration processing of NCAW pretreatment are given in Figure 11-1. The flowsheet batch transfers are shown in Figure 11-2, using the same stream numbering system as Figure 11-1. The material balance for this flowsheet is presented in Table 11-1.

The flowsheet values are established for average plant operating conditions and feed compositions. The values are set to provide safe, efficient operating conditions, minimize waste stream volumes, and achieve effective waste partitioning to meet HWVP, Grout, and overall Waste Management needs. Since this flowsheet is intended to support demonstration processing in B Plant, alterations in a number of parameters should be expected by B Plant Process Engineering, to optimize or monitor the process reactions. These will be controlled through appropriate operational documentation with proper approval authority.

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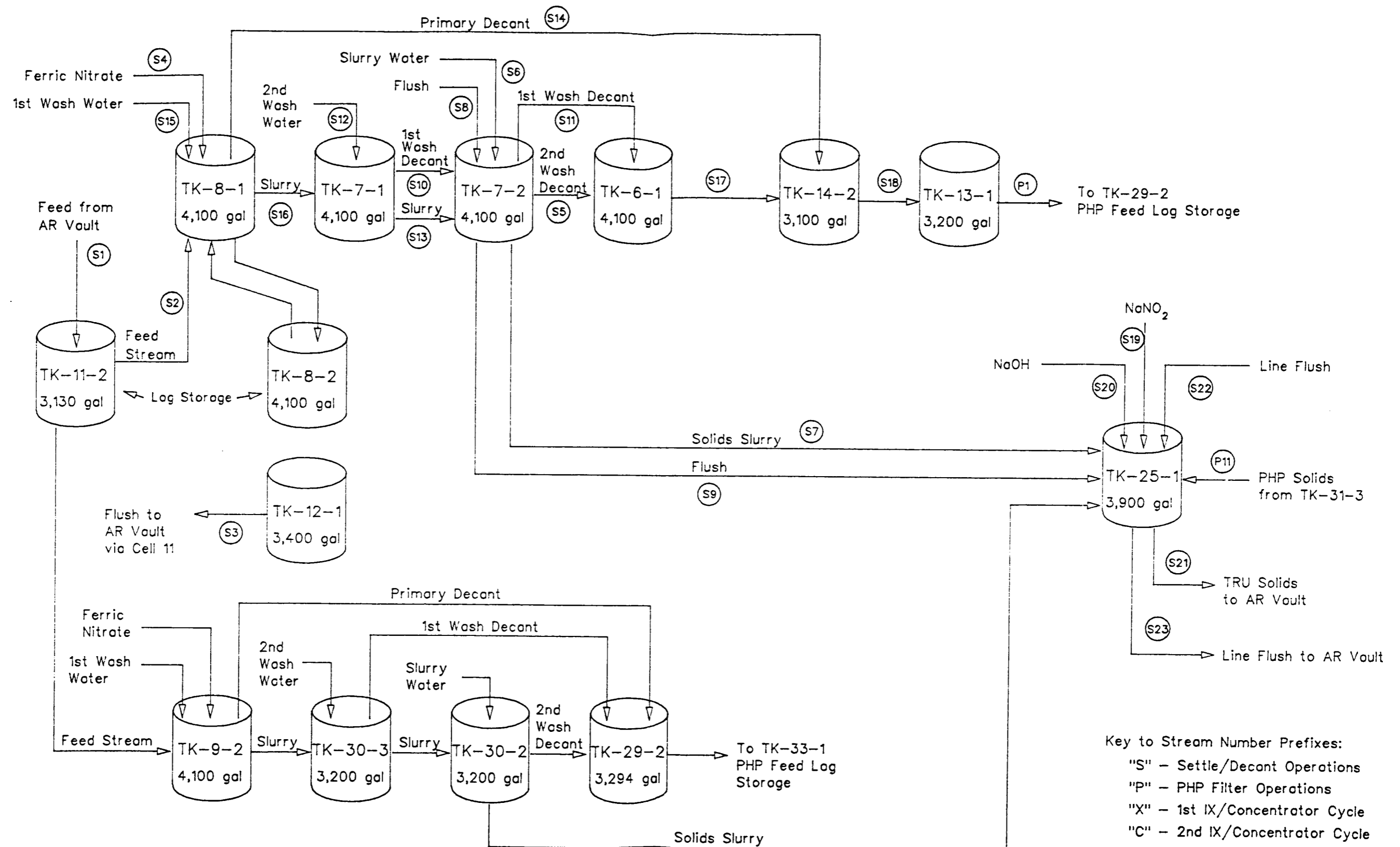


Figure 11-1. NCAW Pretreatment at B Plant (Sheet 1 of 4)  
Settle/Decant/TRU Solids Transfer Operations

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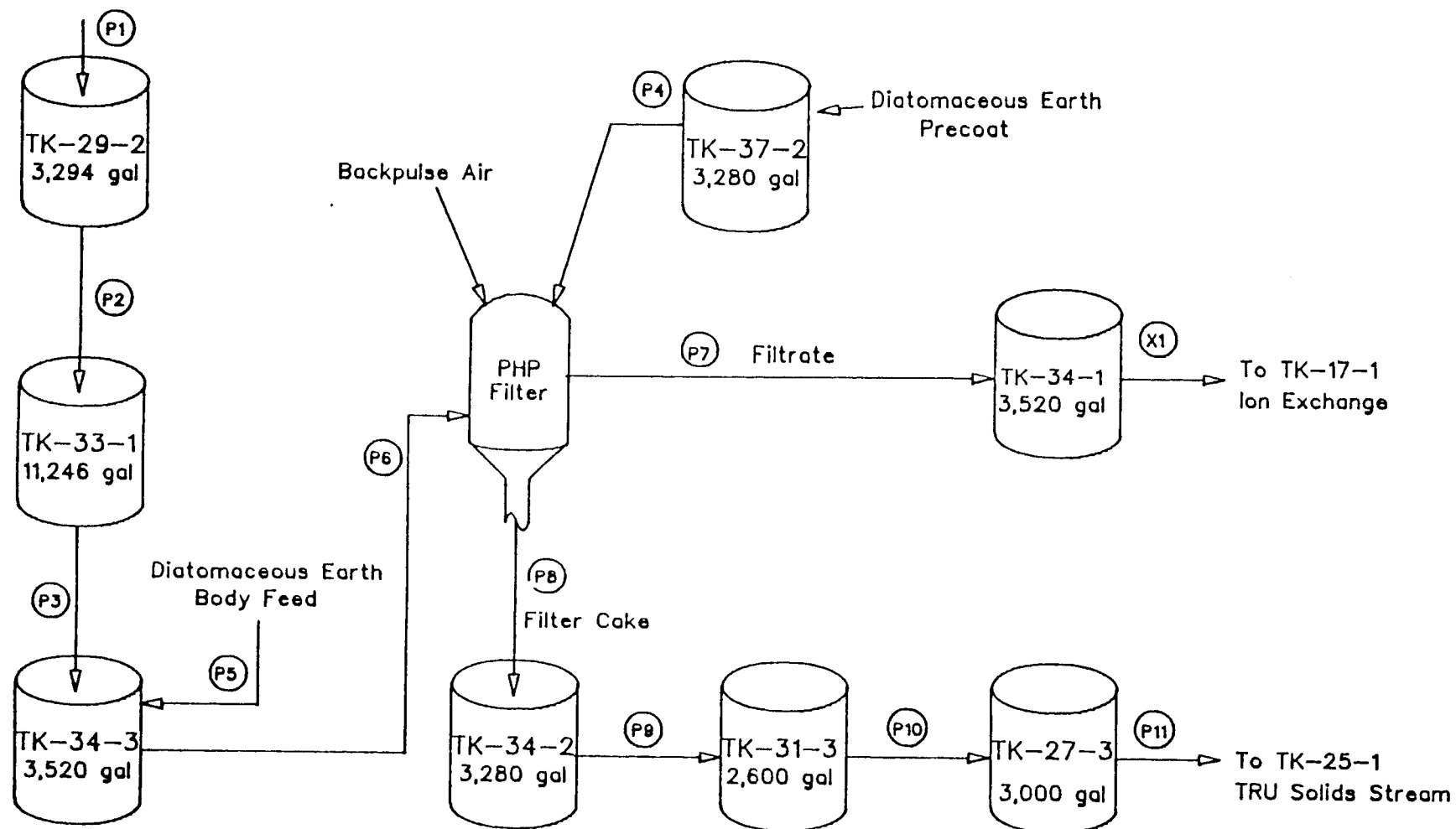


Figure 11-1. NCAW Pretreatment at B Plant (Sheet 2 of 4)  
Pneumatic Hydropulse (PHP) Filter Operations

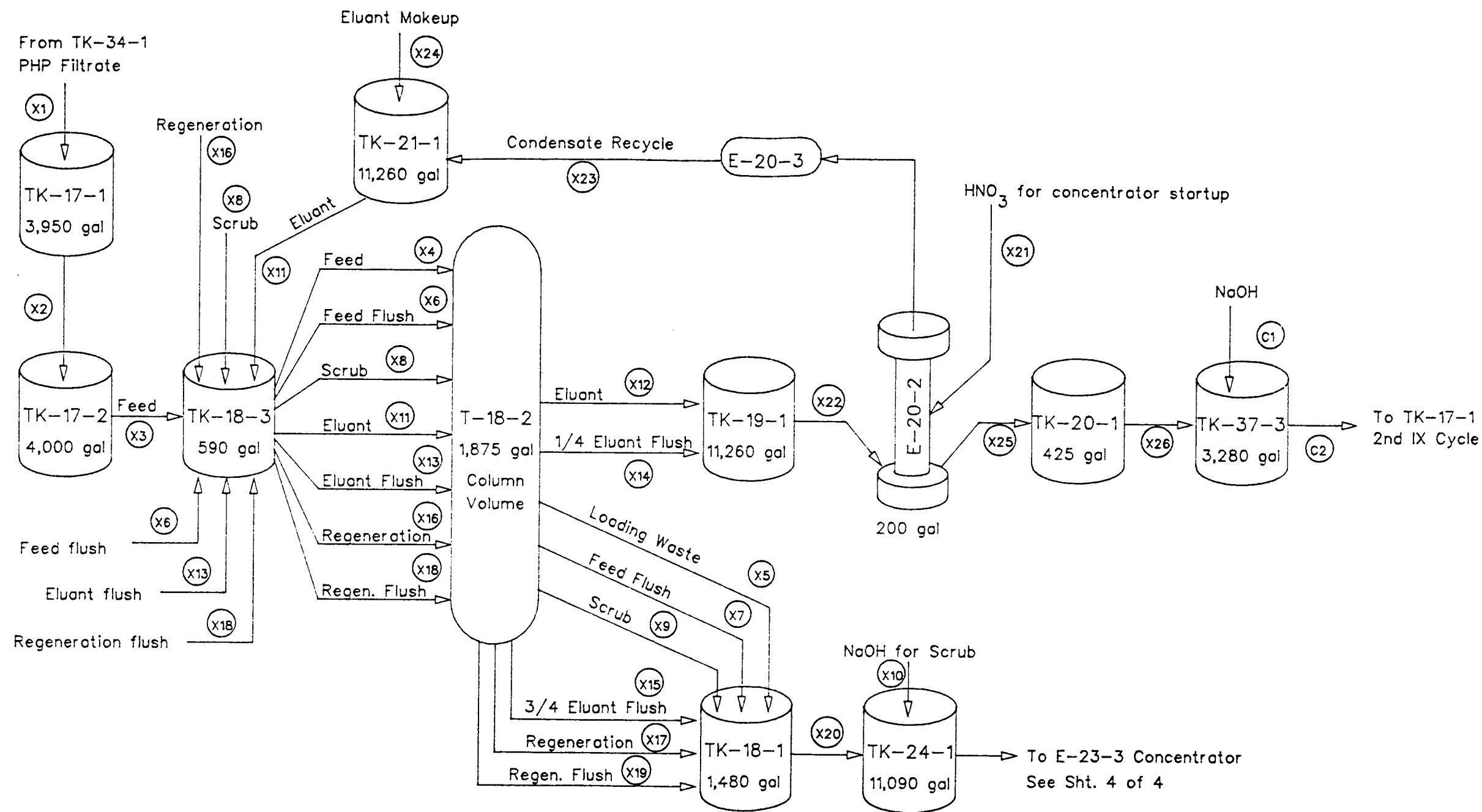


Figure 11-1. NCAW Pretreatment at B Plant (Sheet 3 of 4)  
First Cycle Ion Exchange/Concentrator Operations

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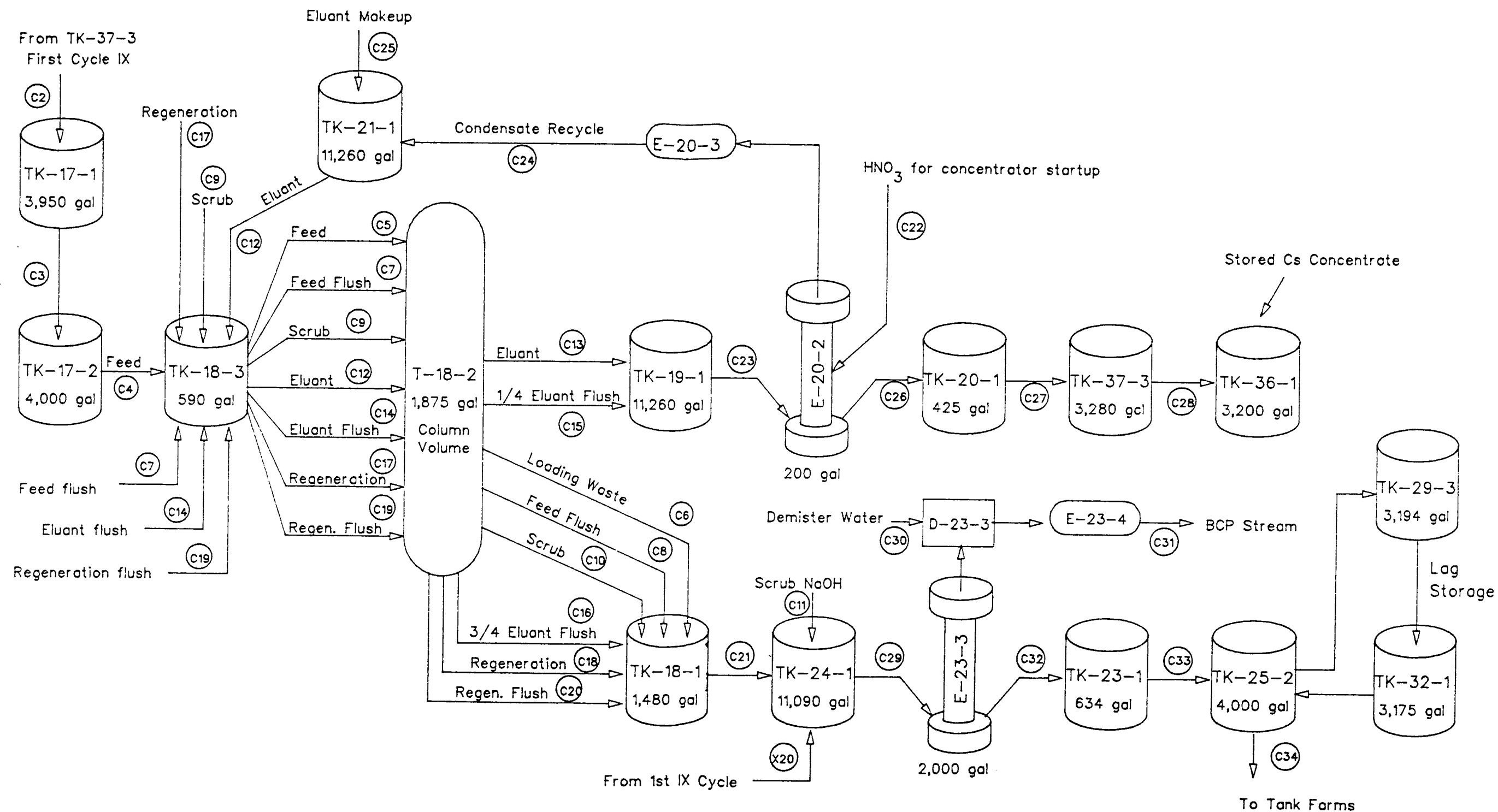


Figure 11-1. NCAW Pretreatment at B Plant (Sheet 4 of 4)  
Second Cycle Ion Exchange/Concentrator Operations

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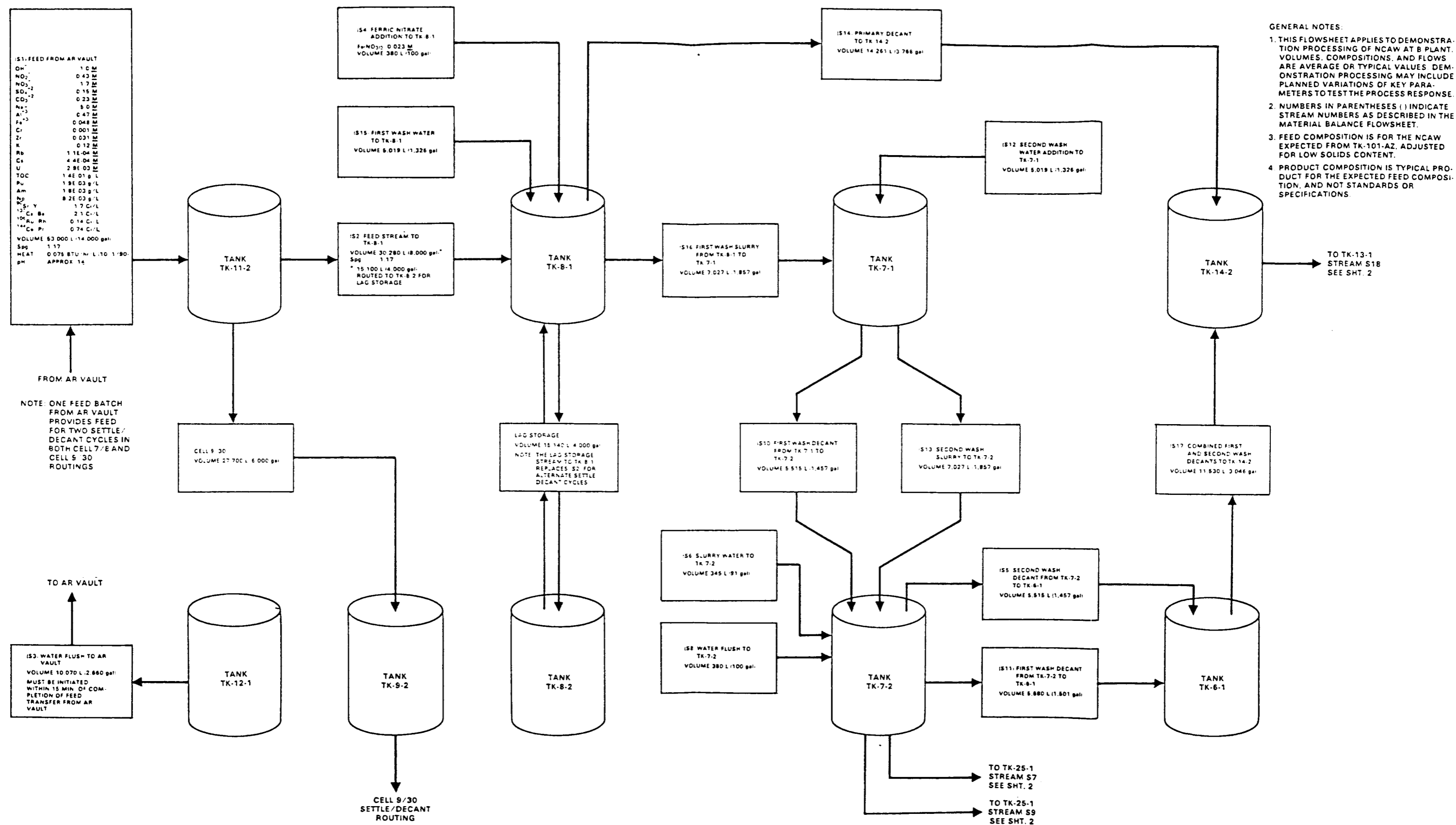


Figure 11-2. Settle/Decant Batch Transfers (Sheet 1 of 6)

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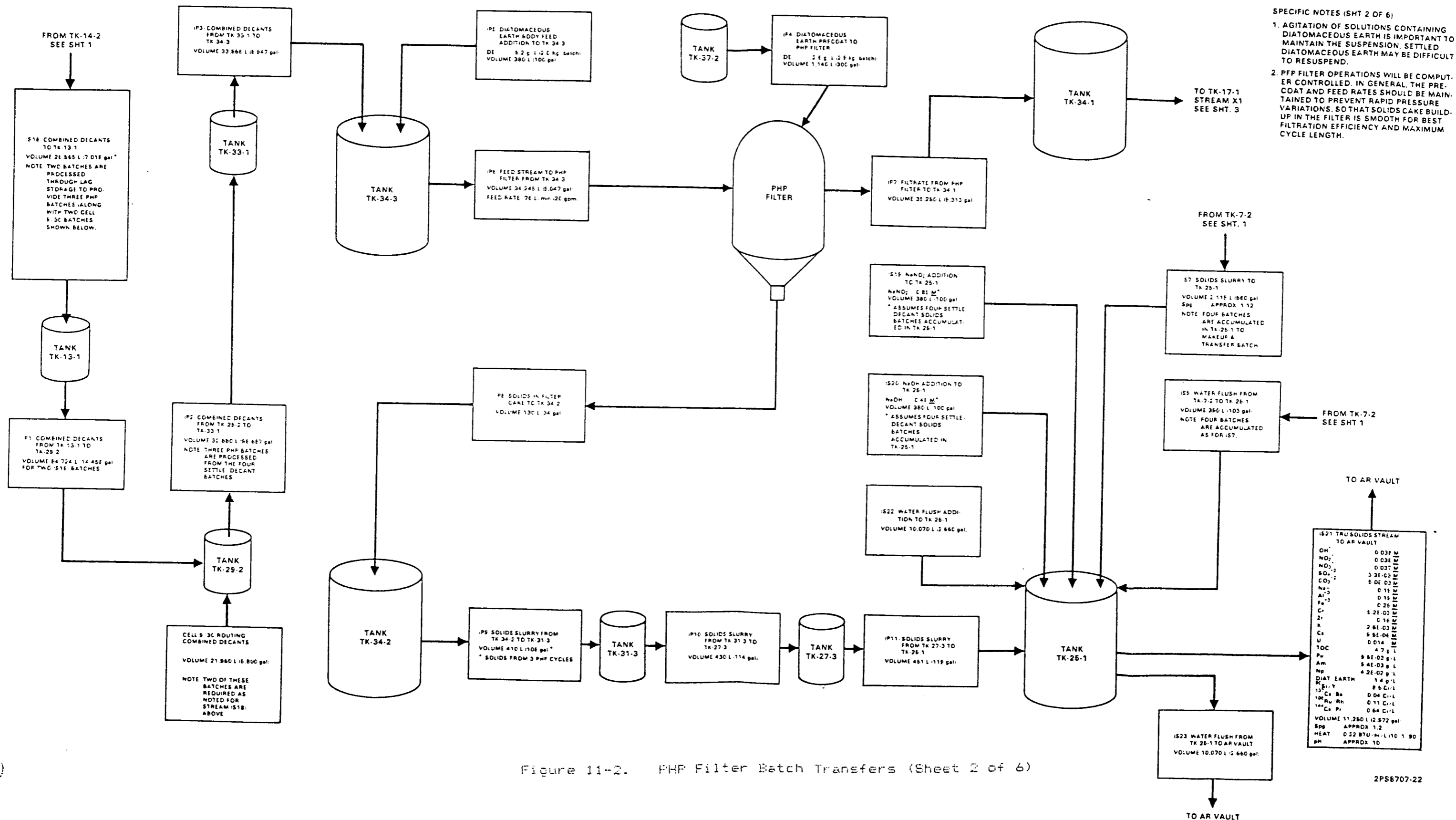


Figure 11-2. PHP Filter Batch Transfers (Sheet 2 of 6)

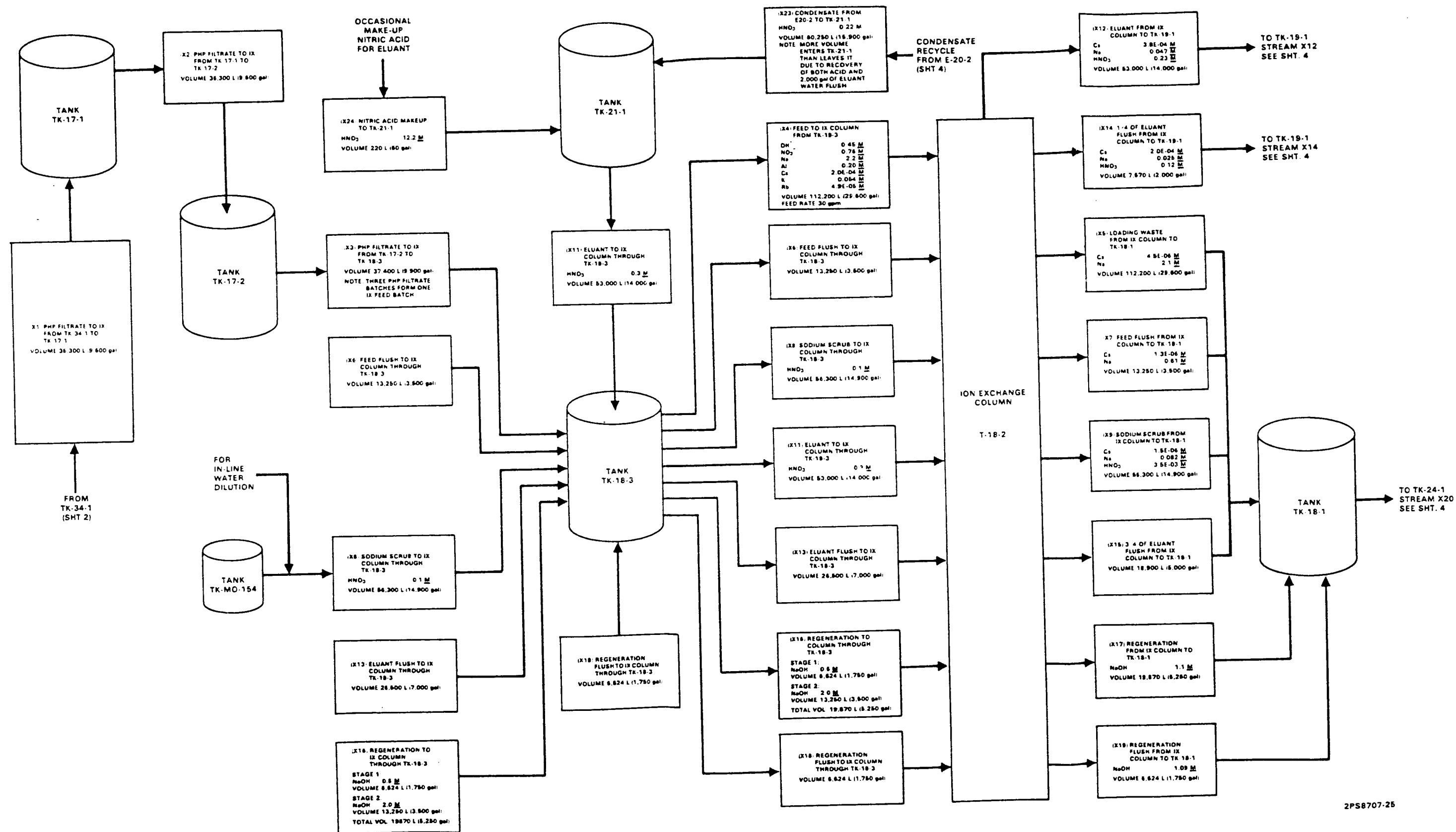
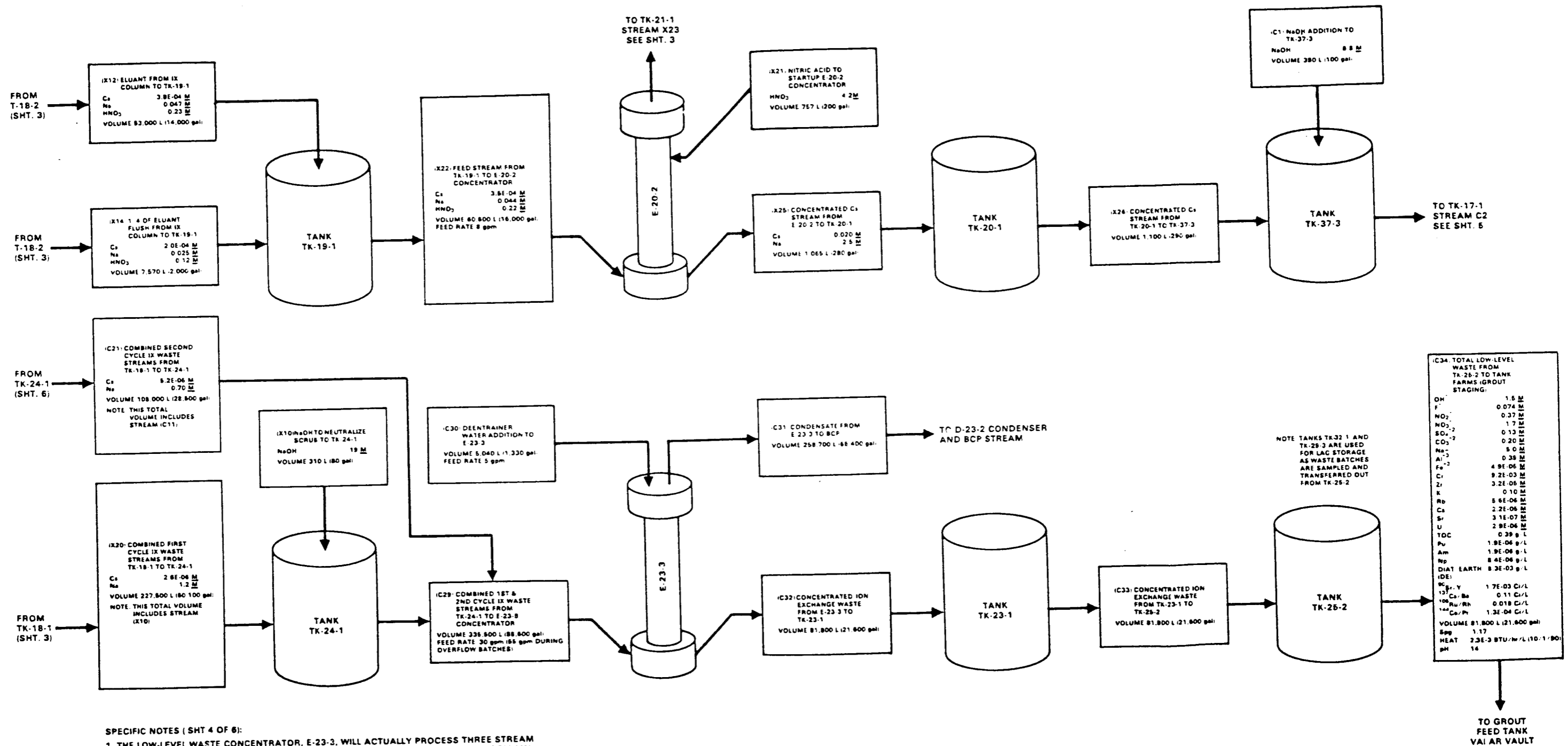


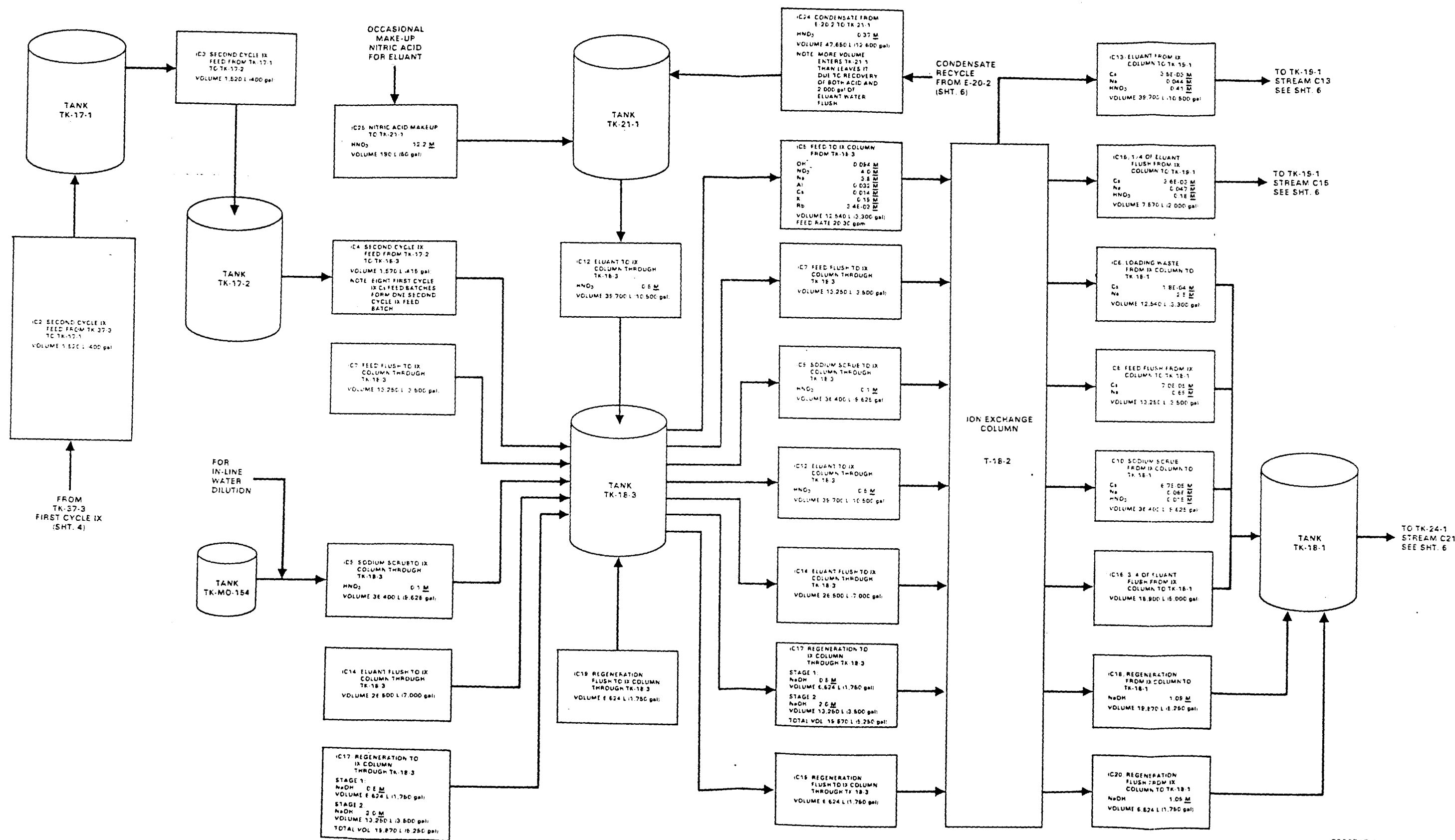
Figure 11-2. First Cycle Ion Exchange Batch Transfers (Sheet 3 of 6)



**SPECIFIC NOTES (SHT 4 OF 6):**

1. THE LOW-LEVEL WASTE CONCENTRATOR, E-23-3, WILL ACTUALLY PROCESS THREE STREAM MIXTURES SEPARATELY AS THEY BECOME AVAILABLE FROM THE ION EXCHANGE COLUMN:
  - (1) MIXTURE OF LOADING WASTE AND FEED FLUSH;
  - (2) SODIUM SCRUB SOLUTION, AND
  - (3) MIXTURE OF PORTION OF ELUTION FLUSH AND REGENERATION AND REGENERATION FLUSH SOLUTIONS.

Figure 11-2. Concentrator Batch Transfers for 1st IX Cycle Waste (Sheet 4 of 6)



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Figure 11-2. Second Cycle IX Batch Transfers (Sheet 5 of 6)

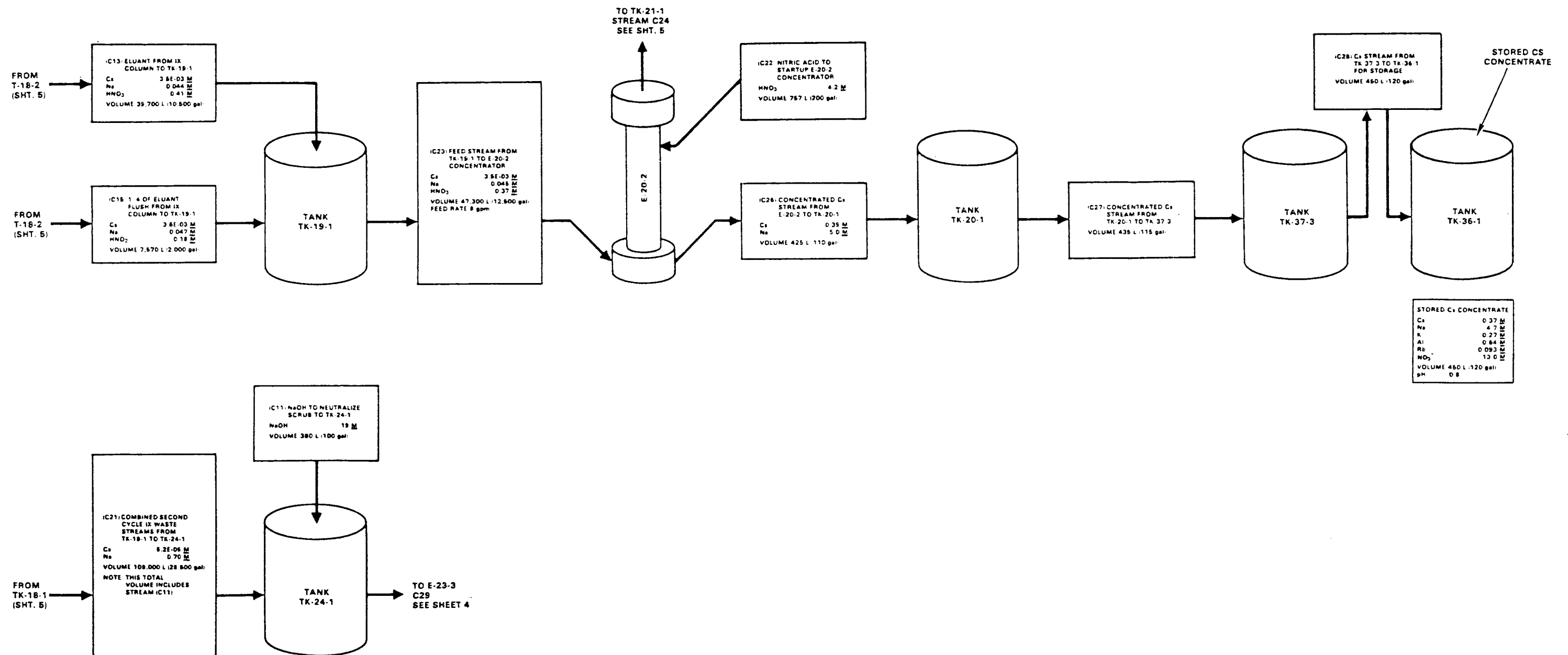


Figure 11-2. Concentrator Batch Transfers for 2nd IX Cycle Waste (Sheet 6 of 6)

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Table 11-1.  
Material Balance Table  
4 vol% Settled Solids Feed

Component (mol/L)	Stream Numbers -->>>									
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
OH-	1.0E+00	9.5E-01			3.3E-03		2.6E-03			1.5E-02
F-	8.7E-02	8.3E-02			2.9E-04		2.3E-04			1.8E-03
NO2-	4.8E-01	4.1E-01			1.4E-03		1.1E-03			6.4E-03
NO3-	1.7E+00	1.6E+00		2.3E-02	5.6E-03		4.5E-03			2.5E-02
SO4-2	1.5E-01	1.4E-01			4.9E-04		4.0E-04			2.2E-03
CO3-2	2.3E-01	2.2E-01			7.6E-04		6.1E-04			3.4E-03
Na+	5.0E+00	4.8E+00			1.6E-02		1.3E-02			7.4E-02
Al	4.9E-01	4.7E-01			2.6E-03		2.3E-01			7.9E-03
Cr	1.2E-02	1.1E-02			6.1E-05		5.4E-03			1.9E-04
Fe+3	4.8E-02	4.6E-02		2.3E-02	1.5E-03		3.1E-01			1.5E-03
Sr	3.0E-04	2.9E-04			9.3E-06		2.0E-03			9.4E-06
Zr	2.1E-02	3.0E-02			9.7E-04		2.1E-01			9.9E-04
Cs	4.4E-04	4.2E-04			1.4E-06		1.2E-06			6.5E-06
K	1.2E-01	1.1E-01			4.0E-04		3.2E-04			1.8E-03
Rb	1.1E-04	1.0E-04			3.6E-07		2.9E-07			1.6E-06
U	2.8E-03	2.7E-03			8.7E-05		1.9E-02			8.9E-05
(g/L)										
TOC	1.4E+00	1.3E+00			3.0E-02		6.0E+00			3.6E-02
Pu	1.9E-03	1.8E-03			5.7E-05		1.2E-02			5.8E-05
Am	1.8E-03	1.7E-03			5.7E-05		1.2E-02			5.8E-05
Np	8.2E-03	7.8E-03			2.5E-04		5.4E-02			2.6E-04
Diat Earth (DE)										
Isotopes Decayed to 10/1/90, (Ci/L)										
90Sr/Y	1.7E+00	1.6E+00			5.2E-02		1.1E+01			5.2E-02
137Cs/Ba	2.0E+00	1.9E+00			6.5E-03		5.3E-03			2.9E-02
106Ru/Rh	4.3E-02	4.1E-02			7.3E-04		1.4E-01			9.9E-04
144Ce/Pr	1.2E-01	1.2E-01			2.9E-03		8.2E-01			3.9E-03
Volume (L)	52,985	15,139	10,068	380	5,515	345	2,119	379	390	5,515
(gal)	13,999	4,000	2,660	100	1,457	91	560	100	103	1,457

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Table 11-1.  
Material Balance Table  
4 vol% Settled Solids Feed

Component	S11.	S12.	S13	S14	S15	S16.	S17	S18.	S19.	S20.
(mol/L)										
OH-	1.4E-02		3.4E-03	1.0E+00		1.5E-02	8.7E-03	3.8E-03		4.8E-01
F-	1.8E-03		2.9E-04	8.7E-02		1.3E-03	7.6E-04	3.3E-04		
NO2-	6.2E-03		1.5E-03	4.3E-01		6.5E-03	3.7E-03	1.6E-03	8.5E-01	
NO3-	2.5E-02		5.7E-03	1.7E+00		2.6E-02	1.5E-02	6.4E-03		
SO4-2	2.2E-03		5.1E-04	1.5E-01		2.3E-03	1.3E-03	5.7E-04		
CO3-2	3.3E-03		7.8E-04	2.3E-01		3.5E-03	2.0E-03	8.7E-04		
Na+	7.2E-02		1.7E-02	5.0E+00		7.5E-02	4.9E-02	1.9E-02	8.5E-01	4.8E-01
Al	7.6E-03		7.0E-02	4.6E-01		7.6E-02	5.0E-03	2.2E-03		
Cr	1.8E-04		1.7E-03	1.1E-02		1.8E-03	1.2E-04	5.2E-05		
Fe+3	1.5E-03		9.6E-02	5.8E-04		9.7E-02	1.4E-03	6.2E-04		
Sr	9.1E-06		6.0E-04	3.6E-06		6.1E-04	8.9E-06	3.9E-06		
Zr	9.6E-04		6.3E-02	3.8E-04		6.4E-02	9.4E-04	4.1E-04		
Cs	6.3E-06		1.5E-06	4.4E-04		6.6E-06	3.8E-06	1.6E-06		
K	1.7E-03		4.1E-04	1.2E-01		1.8E-03	1.0E-03	4.5E-04		
Rb	1.6E-06		3.7E-07	1.1E-04		1.7E-06	9.6E-07	4.1E-07		
U	8.6E-05		5.6E-03	3.4E-05		5.7E-03	8.4E-05	3.7E-05		
(g/L)										
TOC	3.5E-02		1.8E+00	4.7E-01		1.9E+00	3.1E-02	1.4E-02		
Pu	5.6E-05		3.7E-03	2.2E-05		3.8E-03	5.5E-05	2.4E-05		
Am	5.6E-05		3.7E-03	2.2E-05		3.7E-03	5.5E-05	2.4E-05		
Np	2.5E-04		1.6E-02	1.0E-04		1.7E-02	2.4E-04	1.1E-04		
Diat Earth (DE)										
Isotopes Decayed to 10/1/90, (Ci/L)										
90Sr/Y	5.1E-02		3.3E+00	2.0E-02		3.4E+00	5.0E-02	2.2E-02		
137Cs/Ba	2.9E-02		6.7E-03	2.0E+00		3.0E-02	1.7E-02	7.5E-03		
106Ru/Rh	9.6E-04		4.3E-02	2.2E-02		4.4E-02	8.2E-04	3.6E-04		
144Ce/Pr	3.8E-03		2.5E-01	1.5E-03		2.5E-01	3.7E-03	1.6E-03		
Volume (L)	5,680	5,019	7,027	14,261	5,019	7,027	11,530	26,565	380	380
(gal)	1,501	1,326	1,857	3,768	1,326	1,857	3,046	7,018	100	100

Table 11-1.  
Material Balance Table  
4 vol% Settled Solids Feed

Component	S21	S22	S23	P1	P2	P3	P4	P5	P6	P7
(mol/L)										
OH-	3.8E-02			3.7E-03	3.6E-03	3.4E-03			3.4E-03	4.8E-01
F-	1.9E-03			3.2E-04	3.1E-04	3.0E-04			3.0E-04	4.1E-02
NO2-	3.8E-02			1.6E-03	1.5E-03	1.5E-03			1.5E-03	2.0E-01
NO3-	3.7E-02			6.2E-03	6.0E-03	5.9E-03			5.8E-03	8.1E-01
SO4-2	3.3E-03			5.5E-04	5.3E-04	5.2E-04			5.1E-04	7.1E-02
CO3-2	5.0E-03			8.4E-04	8.2E-04	7.9E-04			7.8E-04	1.1E-01
Na+	1.5E-01			1.8E-02	1.8E-02	1.7E-02			1.7E-02	2.4E+00
Al	1.9E-01			2.1E-03	2.0E-03	2.0E-03			2.0E-03	2.2E-01
Cr	5.2E-03			5.0E-05	4.9E-05	4.7E-05			4.7E-05	5.2E-03
Fe+3	2.5E-01			6.0E-04	5.8E-04	5.7E-04			5.6E-04	2.7E-05
Sr	1.5E-03			3.8E-06	3.7E-06	3.6E-06			3.5E-06	1.7E-07
Zr	1.6E-01			4.0E-04	3.8E-04	3.7E-04			3.7E-04	1.8E-05
Cs	9.5E-06			1.6E-06	1.6E-06	1.5E-06			1.5E-06	2.1E-04
K	2.6E-03			4.4E-04	4.3E-04	4.1E-04			4.1E-04	5.7E-02
Rb	2.4E-06			4.0E-07	3.9E-07	3.8E-07			3.8E-07	5.2E-05
U	1.4E-02			3.5E-05	3.4E-05	3.3E-05			3.3E-05	1.6E-06
(g/L)										
TOC	4.7E+00			1.3E-02	1.3E-02	1.2E-02			1.2E-02	2.2E-01
Pu	9.5E-03			2.3E-05	2.3E-05	2.2E-05			2.2E-05	1.1E-06
Am	9.4E-03			2.3E-05	2.2E-05	2.2E-05			2.1E-05	1.0E-06
Np	4.2E-02			1.0E-04	1.0E-04	9.7E-05			9.6E-05	4.7E-06
Diat. Earth (DE)	1.4E+00			0.0E+00	0.0E+00	0.0E+00	2.6E+00	5.2E+00	1.4E-01	4.6E-03
Isotopes Decayed to 10/1/90, (Ci/L)										
90Sr/Y	8.5E+00			2.1E-02	2.0E-02	2.0E-02			2.0E-02	9.5E-04
137Cs/Ba	4.3E-02			7.3E-03	7.0E-03	6.8E-03			6.8E-03	9.4E-01
106Ru/Rh	1.1E-01			3.5E-04	3.4E-04	3.3E-04			3.2E-04	1.0E-02
144Ce/Pr	6.4E-01			1.6E-03	1.5E-03	1.5E-03			1.5E-03	7.1E-05
Volume (L)	11,248	10,068	10,068	54,724	32,880	33,866	1,136	379	34,245	35,250
(gal)	2,972	2,660	2,660	14,458	8,687	8,947	300	100	9,047	9,318

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Table 11-1.  
Material Balance Table  
4 vol% Settled Solids Feed

Component	P8.	P9.	P10.	P11.	X1.	X2.	X3.	X4.	X5.	X6.
(mol/L)										
OH-	5.0E-01	4.7E-01	4.5E-01	4.3E-01	4.6E-01	4.6E-01	4.5E-01	4.5E-01	4.3E-01	
F-	4.3E-02	4.1E-02	3.9E-02	3.7E-02	4.0E-02	4.0E-02	3.9E-02	3.9E-02	3.8E-02	
NO2-	2.1E-01	2.0E-01	1.9E-01	1.8E-01	2.0E-01	2.0E-01	1.9E-01	1.9E-01	1.9E-01	
NO3-	8.4E-01	8.0E-01	7.7E-01	7.3E-01	7.8E-01	7.8E-01	7.6E-01	7.6E-01	7.4E-01	
SO4-2	7.4E-02	7.1E-02	6.8E-02	6.4E-02	6.9E-02	6.9E-02	6.7E-02	6.7E-02	6.5E-02	
CO3-2	1.1E-01	1.1E-01	1.0E-01	9.9E-02	1.1E-01	1.1E-01	1.0E-01	1.0E-01	1.0E-01	
Na+	2.5E+00	2.4E+00	2.3E+00	2.1E+00	2.3E+00	2.3E+00	2.2E+00	2.2E+00	2.1E+00	
Al	3.8E-01	3.6E-01	3.4E-01	3.3E-01	2.1E-01	2.1E-01	2.0E-01	2.0E-01	2.0E-01	
Cr	9.1E-03	8.7E-03	8.2E-03	7.8E-03	5.0E-03	5.0E-03	4.9E-03	4.9E-03	4.7E-03	
Fe+3	2.1E-01	2.0E-01	1.9E-01	1.9E-01	2.6E-05	2.6E-05	2.6E-05	2.6E-05	2.5E-05	
Sr	1.3E-03	1.3E-03	1.2E-03	1.2E-03	1.7E-07	1.7E-07	1.6E-07	1.6E-07	1.6E-07	
Zr	1.4E-01	1.3E-01	1.3E-01	1.2E-01	1.7E-05	1.7E-05	1.7E-05	1.7E-05	1.6E-05	
Ca	2.2E-04	2.1E-04	2.0E-04	1.9E-04	2.0E-04	2.0E-04	2.0E-04	2.0E-04	4.5E-06	
K	6.0E-02	5.7E-02	5.4E-02	5.1E-02	5.5E-02	5.5E-02	5.4E-02	5.4E-02	4.7E-02	
Rb	5.5E-05	5.2E-05	5.0E-05	4.7E-05	5.1E-05	5.1E-05	4.9E-05	4.9E-05	1.1E-06	
U	1.3E-02	1.2E-02	1.1E-02	1.1E-02	1.6E-06	1.6E-06	1.5E-06	1.5E-06	1.5E-06	
(g/L)										
TDC	4.4E+00	4.2E+00	4.0E+00	3.8E+00	2.1E-01	2.1E-01	2.0E-01	2.0E-01	2.0E-01	
Pu	8.3E-03	7.9E-03	7.5E-03	7.2E-03	1.0E-06	1.0E-06	1.0E-06	1.0E-06	9.6E-07	
Am	8.2E-03	7.8E-03	7.5E-03	7.1E-03	1.0E-06	1.0E-06	9.9E-07	9.9E-07	9.5E-07	
Np	3.7E-02	3.5E-02	3.3E-02	3.2E-02	4.5E-06	4.5E-06	4.4E-06	4.4E-06	4.3E-06	
Diat Earth (DE)	3.6E+01	3.5E+01	3.3E+01	3.1E+01	4.5E-03	4.5E-03	4.4E-03	4.4E-03	4.2E-03	
Isotopes Decayed to 10/1/90, (Ci/L)										
90Sr/Y	7.5E+00	7.1E+00	6.8E+00	6.5E+00	9.2E-04	9.2E-04	9.0E-04	9.0E-04	8.7E-04	
137Cs/Ba	9.8E-01	9.4E-01	8.9E-01	8.5E-01	9.2E-01	9.2E-01	8.9E-01	8.9E-01	2.0E-02	
106Ru/Rh	1.1E-01	1.0E-01	9.7E-02	9.2E-02	9.9E-03	9.9E-03	9.6E-03	9.6E-03	9.3E-03	
144Ce/Pr	5.6E-01	5.3E-01	5.1E-01	4.8E-01	6.9E-05	6.9E-05	6.7E-05	6.7E-05	6.5E-05	
Volume (L)	120	410	430	451	36,308	36,308	37,397	112,191	112,191	13,247
(gall)	34	108	114	119	9,593	9,593	9,880	29,641	29,641	3,500

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Table 11-1.  
Material Balance Table  
4 vol% Settled Solids Feed

Component	X7.	X8.	X9.	X10.	X11.	X12.	X13.	X14.	X15.	X16.
(mol/L)										
OH-	1.3E-01			1.9E+01						1.0E+00
F-	1.1E-02									
NO2-	5.4E-02									
NO3-	2.1E-01	1.0E-01	9.3E-02		3.0E-01	2.9E-01		1.5E-01		
SO4-2	1.9E-02									
CO3-2	2.9E-02									
Na+	6.1E-01		8.2E-02	1.9E+01		4.7E-02		2.5E-02		1.0E+00
Al	5.7E-02		2.4E-03			8.8E-04		4.7E-04		
Cr	1.4E-03									
Fe+3	7.2E-06									
Sr	4.5E-08									
Zr	4.7E-06									
Cs	1.3E-06		1.5E-06			3.8E-04		2.0E-04		
K	1.4E-02		5.4E-03			5.3E-03		2.8E-03		
Rb	3.2E-07		3.8E-07			9.4E-05		5.0E-05		
U	4.2E-07									
(g/L)										
TOC	5.7E-02									
Pu	2.8E-07									
Am	2.8E-07									
Np	1.2E-06									
Diat. Earth (DE)	1.2E-03									
Isotopes Decayed to 10/1/90, (Ci/L)										
90Sr/Y	2.5E-04									
137Cs/Ba	5.8E-03		6.9E-03			1.7E+00		9.0E-01		
106Ru/Rh	2.7E-03									
144Ce/Pr	1.9E-05									
Volume (L)	13,247	56,302	56,302	907	52,990	52,990	26,495	7,570	18,925	19,871
(gal)	3,500	14,875	14,875	81	14,000	14,000	7,000	2,000	5,000	5,250

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Table 11-1.  
Material Balance Table  
4 vol% Settled Solids Feed

Component	X17.	X18.	X19.	X20.	X21.	X22.	X23.	X24.	X25.	X26.
(mol/L)										
DH-	1.1E+00		1.1E+00	3.7E-01						
F-				1.9E-02						
NO2-				9.5E-02						
NO3-				4.0E-01		2.7E-01	2.2E-01	1.2E+01	5.8E+00	5.7E+00
SO4-2				3.3E-02						
CO3-2				5.1E-02						
Na+	1.1E+00		1.1E+00	1.2E+00		4.4E-02			2.5E+00	2.4E+00
Al				1.0E-01		8.3E-04			4.7E-02	4.6E-02
Cr				2.4E-03						
Fe+3				1.3E-03						
Sr				8.0E-08						
Zr				8.3E-06						
Cs				2.6E-06		3.5E-04			2.0E-02	1.9E-02
K				2.5E-02		5.0E-03			2.8E-01	2.7E-01
Rb				6.7E-07		8.9E-05			5.0E-03	4.9E-03
U				6.2E-04						
(g/L)										
TOC				1.0E-01						
Pu				4.9E-07						
Am				4.5E-07						
Np				2.2E-06						
Diat Earth (DE)				2.2E-03						
Isotopes Decayed to 10/1/90, (Ci/L)										
90Sr/Y				4.4E-04						
137Cs/Ba				1.2E-02		1.6E+00			9.1E+01	8.8E+01
106Ru/Rh				4.7E-03						
144Ce/Pr				3.3E-03						
Volume (L)	19,871	6,624	6,624	227,467	757	60,560	60,252	219	1,065	1,097
(gal)	5,250	1,750	1,750	60,097	200	16,000	15,919	58	281	290

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Table 11-1.  
Material Balance Table  
4 vol% Settled Solids Feed

Component	C1.	C2.	C3.	C4.	C5.	C6.	C7.	C8.	C9.	C10.
(mol/L)										
DH-	8.8E+00	9.7E-02	9.7E-02	9.4E-02	9.4E-02	6.6E-02		2.6E-02		
F-										
NO2-										
NO3-		4.1E+00	4.1E+00	4.0E+00	4.0E+00	2.8E+00		1.1E+00		9.0E-02
SO4-2										
CO3-2										
Na+	8.8E+00	3.9E+00	3.9E+00	3.8E+00	3.8E+00	2.5E+00		6.9E-01		6.8E-02
Al		3.3E-02	3.3E-02	3.2E-02	3.2E-02	2.9E-04		1.2E-04		3.0E-03
Cr										
Fe+3										
Sr										
Zr										
Cs		1.4E-02	1.4E-02	1.4E-02	1.4E-02	1.8E-04		7.0E-05		6.7E-05
K		2.0E-01	2.0E-01	1.9E-01	1.9E-01	1.2E-01		4.8E-02		3.3E-03
Rb		3.5E-03	3.5E-03	3.4E-03	3.4E-03	4.4E-05		1.8E-05		1.7E-05
U										
(g/L)										
TOC										
Pu										
Am										
Np										
Diat Earth (DE)										
Isotopes Decayed to 10/1/90, (Ci/L)										
90Sr/Y										
137Cs/Ba		6.4E+01	6.4E+01	6.2E+01	6.2E+01	8.0E-01		3.2E-01		3.0E-01
106Ru/Rh										
144Ce/Pr										
Volume (L)	380	1,522	1,522	1,567	12,537	12,537	13,247	13,247	36,431	36,431
(gal)	100	402	402	414	3,312	3,312	3,500	3,500	9,625	9,625

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Table 11-1.  
Material Balance Table  
4 vol% Settled Solids Feed

Component	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20
(mol/L)										
OH-	1.1E+01						1.5E+00	1.1E+00		1.1E+00
F-										
NO2-										
NO3-		5.0E-01	4.6E-01		2.5E-01					
SO4-2										
CO3-2										
Na+	1.1E+01		4.4E-02		4.7E-02		1.5E+00	1.1E+00		1.1E+00
Al			6.1E-03		6.4E-03					
Cr										
Fe+3										
Sr										
Zr										
Cs			3.5E-03		3.6E-03					
K			2.5E-03		2.7E-03					
Rb			8.7E-04		9.2E-04					
U										
(g/L)										
TDC										
Pu										
Am										
Np										
Diat. Earth (DE)										
Isotopes Decayed to 10/1/90, (Ci/L)										
90Sr/Y										
137Cs/Ba			1.6E+01		1.7E+01					
106Ru/Rh										
144Ce/Pr										
Volume (L)	380	39,743	39,743	26,495	7,570	18,925	19,871	19,871	6,624	6,624
(gall)	100	10,500	10,500	7,000	2,000	5,000	5,250	5,250	1,750	1,750

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Table 11-1.  
Material Balance Table  
4 vol% Settled Solids Feed

Component	C21.	C22.	C23.	C24.	C25.	C26.	C27.	C28.	C29.	C30.
(mol/L)										
OH-	3 2E-01								3 7E-01	
F-									1 8E-02	
NO2-									9 0E-02	
NO3-	4 9E-01	4 2E+00	4 3E-01	3 7E-01	2 8E+02	1 4E+01	1 4E+01	1 3E+01	4 0E-01	
SO4-2									3 1E-02	
CO3-2									4 8E-02	
Na+	7 0E-01		4 5E-02			5 0E+00	4 9E+00	4 7E+00	1 2E+00	
Al	1 1E-03		6 1E-08			6 8E-01	6 6E-01	6 4E-01	9 5E-02	
Cr									2 3E-03	
Fe+3									1 2E-05	
Sr									7 5E-08	
Zr									7 9E-06	
Cs	5 2E-05		3 5E-03			3 9E-01	3 8E-01	3 7E-01	5 4E-06	
K	2 1E-02		2 5E-03			2 8E-01	2 8E-01	2 7E-01	2 5E-02	
Rb	1 3E-05		8 8E-04			9 8E-02	9 5E-02	9 3E-02	1 4E-06	
U									7 1E-07	
(g/L)										
TOC										
Pu									9 5E-02	
Am									4 6E-07	
Np									4 6E-07	
Diat. Earth (DE)									2 1E-06	
									2 0E-03	
Isotopes Decayed to 10/1/90, (Ci/L)										
90Sr/Y									4 2E-04	
137Cs/Ba	2 3E-01		1 6E+01			1 8E+03	1 7E+03	1 7E+03	2 4E-02	
106Ru/Rh									4 5E-03	
144Ce/Pr									3 1E-05	
Volume (L)	108,016	757	47,318	47,646	194	424	496	449	335,482	5,043
(gall)	28,538	200	12,500	12,588	51	112	115	119	88,635	1,332

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Table 11-1.  
Material Balance Table  
4 vol% Settled Solids Feed

Component	C81	C92	C93	C94
(mol/L)				
OH-		1.5E+00	1.5E+00	1.5E+00
F-		7.4E-02	7.4E-02	7.4E-02
NO2-		3.7E-01	3.7E-01	3.7E-01
NO3-		1.7E+00	1.7E+00	1.7E+00
SO4-2		1.3E-01	1.3E-01	1.3E-01
CO3-2		2.0E-01	2.0E-01	2.0E-01
Na+		5.0E+00	5.0E+00	5.0E+00
Al		3.9E-01	3.9E-01	3.9E-01
Cr		9.3E-03	9.3E-03	9.3E-03
Fe+3		4.9E-05	4.9E-05	4.9E-05
Sr		3.1E-07	3.1E-07	3.1E-07
Zr		3.2E-05	3.2E-05	3.2E-05
Cs		2.2E-05	2.2E-05	2.2E-05
K		1.0E-01	1.0E-01	1.0E-01
Rb		5.6E-06	5.6E-06	5.6E-06
U		2.9E-06	2.9E-06	2.9E-06
(g/L)				
TOC		3.9E-01	3.9E-01	3.9E-01
Pu		1.9E-06	1.9E-06	1.9E-06
Am		1.9E-06	1.9E-06	1.9E-06
Np		8.4E-06	8.4E-06	8.4E-06
Diat. Earth (DE)		8.9E-03	8.9E-03	8.9E-03
Isotopes Decayed to 10/1/90, (Ci/L)				
90Sr/Y		1.7E-03	1.7E-03	1.7E-03
137Cs/Ba		1.0E-01	1.0E-01	1.0E-01
106Ru/Rh		1.8E-02	1.8E-02	1.8E-02
144Ce/Pr		1.9E-04	1.9E-04	1.9E-04
Volume (L)	258,737	81,788	81,788	81,788
(gal)	68,359	21,608	21,608	21,608

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## APPENDIX 1

### Assumptions for 4 Vol% Settled Solids Feed

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ASSUMPTIONS (A# is the assumption number referenced in calculations)  
For 4 vol% Settled Solids Feed

Input Stream from AR Vault

A1 Input stream :The components represent the blend in TK-101-AZ,  
the data is from Ltrs 65611-86-039 and -151

A2 Input Stream Volume: 1,453 L/MTU, or 384 gal/MTU  
A3 Batch from AR Vault: 52,990 L, or 14,000 gal  
A4 Solids content: 2.5 wgt% or 25,000 ppm  
A5 Settled Solids volume: 4 % of feed slurry  
A6 Overall Density 1.2 g/cc  
A7 Settled Solids Density 1.25 g/cc  
A8 TK-101-AZ solids: 3.5 wgt%

A9 Input Stream Composition (adjusted for low solids if necessary):  
(Selected components from Table 3-2 below. See Table 3-2 for  
assumed washing behaviour)

Component	B Plant Feed mol/MTU	GMW	
OH-	1,453	17.01	
F-	126	19.00	
NO2-	625	46.01	
NO3-	2,471	62.01	
SO4-2	218	96.06	
CO3-2	334	60.01	
Na+	7,267	22.99	
Al	712	26.98	
Cr	17.0	52.00	
Fe+3	70	55.84	
Sr	0.44	87.62	
Zr	46	91.22	
Cs	0.64	134.90	137 Cs137
K	174		
Rb	0.16		
Misc. solids	1.00		
Misc. solubles	1.00		
U	4.1	238.00	
TOC	1,997 g/MTU	12.00	
Pu	2.69 g/MTU	239.00	
Am	2.66 g/MTU	241.00	
Np	11.93 g/MTU	237.00	
90Sr/Y	2,420 Ci/MTU		
137Cs/Ba	2,883 Ci/MTU		
106Ru/Rh	62 Ci/MTU		
144Ce/Pr	181 Ci/MTU		

There are a number of other components of interest in the  
NCAW stream. All components are tracked by using the 1 mol/MTU  
of miscellaneous solid and soluble components in each stream,  
which are followed in this spreadsheet (chem additions are also  
accounted for where necessary).

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# Water Flush Addition Volumes to Process Tanks

A10	Standard Flush	379	L/batch	100	gal/batch
A11	TK-25-1 Flush to Tank Farms	10,068	L/batch	2,660	gal/batch
A12	TK-12-1 Flush to AR Vault	10,068	L/batch	2,660	gal/batch

# B Plant Facility Parameters

A13	Batch Volume from AR Vault	58,403	L/batch	15,430	gal/batch
A14	Jet Capacity	17,033	L/hr	75	gal/min
A15	Jet rate for decantation	5,678	L/hr	25	gal/min
A16	Typical Pumping rate	17,033	L/hr	75	gal/min
A17	Scale Tank Addition Rate	6,813	L/hr	30	gal/min
A18	Jet Dilution - Liquids			1.03	ratio
A19	Jet Dilution - Solid Slurries			1.05	ratio
A20	Total Operating Efficiency			53 %	TOE

# TRU Isotopic Data - for the mix of fuel in tank 101AZ

A21	Am241 activity	3.43	Ci/g
A22	Pu Alpha Activity	0.098	Ci/g w/max Am241 ingrowth

# Grout Parameters

A23	Ratio Grout Volume to Feed Volume:	1.3 :1
A24	Grout Density:	1.4 g/cc

# Chemical Additions to Process Tanks

A25	Required OH- Molarity in DST	0.02	mol/L
A26	Required NO2- Molarity in DST	0.02	mol/L
A27	NaOH essential materials (EM) conc.	19	mol/L
A28	Minimum chem addition volume	380	L
A29	NaN02 EM concentration	2.5	mol/L
A30	HNO3 EM concentration	12.2	mol/L

# Settle/Decant Assumptions

A31	Decant jet height above SS;	0.23 m or	1,068 L
A32	SS level at rate transition :	30 % greater than final vol%	
A33	Interstitial liquor in SS;	80 volume%	
A34	Primary Tank Volume;	15,519	L
A35	First wash tank effective volume;	15,519	L considering 1 jet diln
A36	Second wash tank effective volume;	15,519	L considering 2 jet dilns
A37	Solids in primary decant;	300	ppm
A38	Solids in wash decants;	300	ppm
A39	1st wash ratio:	3 :1	water:primary tank SS
A40	2nd wash ratio:	3 :1	water:primary tank SS
A41	Maximum solids for pumpability;	30.0	vol% SS
A42	TK-25-1 tank volume;	14,800	L
A43	Slurry batches in TK-25-1;	4	
A44	Density 2nd wash solids slurry;	1.07	g/cc

# Ferric Nitrate Add

A45	Ferric Nitrate addition:	200	ppm
A46	Molecular weight;	407	as a nonohydrate

# Time Cycle Assumptions for settle/decant

A47	Settling Rate For Primary Tank:	5.0	cm/hr
A48	Settling Rate For Wash Tank:	10.2	cm/hr
A49	Agitate/Slurry Time:	2	hr
A50	Settling Tank Radius:	1.22	m

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A51 Head Required to Jet: 1,890 L

Inverted PHP Filter Assumptions:

A52 Filter size; 6.51 sq m surface area  
A53 Filter/Backflush volume; 130 L  
A54 Precoat amount; 452 g/sq m/cycle  
A55 Body feed addition; 0.25 : 1 DE to solids  
A56 Agitation Of Body Feed: 0.5 hr  
A57 Time for backflush cycle; 0.083 hr/cycle  
A58 Precoat addition volume; 1,136 L/cycle  
A59 Body Feed Addition Volume: 379 L/cycle  
A60 Filtrate clarity (average); 10 ppm in filtrate  
A61 Feed Rate (filtrate rate); 4,542 L/hr, 0.29 g/min/sq ft  
A62 Cell 9/30 to Cell 7/8 rates; 0.75 ratio  
A63 Lag storage between PHP and IX; 45,647 L

Diatomaceous Earth (DE) composition (SiO<sub>2</sub> is balance)

A64 Component Weight %  
Na<sub>2</sub>O 0.55  
Al<sub>2</sub>O<sub>3</sub> 4  
Fe<sub>2</sub>O<sub>3</sub> 1.3  
Misc. 2.55

Ion Exchange Assumptions:

A65 Plug flow conditions except for the ions which are exchanged  
A66 Feed rate: 6,813 L/hr or 30 gpm  
A67 Column volume: 6,624 L or 1,750 gallons  
A68 Bed (resin void) volume: 3,709 L or 980 gallons  
A69 S/D cycles to match PHP & IX 2 S/D cycles  
A70 Vol. Limit, 2nd cycle feed: 14,023 L  
A71 Cs-137 specific activity: 86.6 Ci/g  
A72 Cs-137 / Cesium mol ratio: 0.38 Cs137/Cs

Component Splits in Ion Exchange Streams

Percentages for Rb are assumed to be the same as for Cs  
(percent of component in ion exchange feed stream)

A73 First IX Cycle

Component	Loading Waste & Flush	Sodium Scrub	Cesium Elution & Flush
Cs	2.35	0.39	97.26
Na	97.11	1.84	1.06
Al	99.17	0.6	0.22
K	90.0	5.0	5.0

A74 Second IX Cycle

Component	Loading Waste & Flush	Sodium Scrub	Cesium Elution & Flush
Cs	1.84	1.43	96.73
Na	90.4	5.18	4.42
Al	1.3	27.04	71.7
K	90.0	5.0	5.0

A75 Required OH<sup>-</sup> to feed 2nd IX cycle: 0.1 molar

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A76	Feed flush volume, 1st cycle:	2 col volumes/batch
A77	Feed flush volume, 2nd cycle:	2 col volumes/batch
A78	Sodium scrub composition:	0.1 Molar HNO <sub>3</sub>
A79	Sodium scrub volume, 1st cycle:	8.5 col volumes/batch
A80	Sodium scrub volume, 2nd cycle:	5.5 col volumes/batch
A81	1st cycle Cs elution composition:	0.3 Molar HNO <sub>3</sub>
A82	2nd cycle Cs elution composition:	0.5 Molar HNO <sub>3</sub>
A83	Cesium elution volume, 1st cycle:	8 col volumes/batch
A84	Cesium elution volume, 2nd cycle:	6 col volumes/batch
A85	Eluent flush volume:	4 col volumes/batch
Regeneration volume and composition (NaOH):		
A86	1st stage:	0.5 mol/L 1 col volumes/batch
A87	2nd, 1st cycle;	2.0 mol/L 2 col volumes/batch
A88	2nd, 2nd cycle;	2.0 mol/L 2 col volumes/batch
A89	Regeneration flush volume:	1 col volumes/batch

#### Concentrator Assumptions

A90	LLW and 2nd Cs eluent are concentrated to:	5 mol/L Na	
A91	1st IX cycle Cs eluent is concentrated to:	2.5 mol/L Na	
A92	Start-up molarity in E-23-3 after flushed:	2 mol/L Na	
A93	Start-up molarity in E-20-2 after emptied:	0 mol/L Na	
A94	HNO <sub>3</sub> start-up molarity in E-20-2:	4.2 mol/L HNO <sub>3</sub>	
A95	Nitric acid recovery, 1st IX cycle:	100 %	
A96	Nitric acid recovery, 2nd IX cycle:	100 %	
A97	Deentrainer water add for E-23-3:	1,136 L/hr	
A98	Flush to T-18-2 to send eluant to TK-19-1;	7,570 L or	2000 gal
A99	Feed rate to E-23-3 during buildup:	6,813 L/hr or	30 gpm
A100	Feed rate to E-20-2:	1,817 L/hr or	8 gpm
A101	Volume for pump head:	3,785 L	
A102	Start-up time for concentrator:	1 hr	
A103	Feed rate to E-23-3 during overflow;	12,491 L/hr or	55 gpm
A104	Overhead boil off rate from E-23-3 concen;	7,949 L/hr or	35 gpm
A105	Pot volume in E-20-2:	757 L or	200 gal
A106	Pot volume in E-23-3:	7,570 L or	2,000 gal
A107	Volume overflowed from E-23-3 concen;	1,893 L or	500 gal
A108	Time to cool E-20-2 before jetting;	1 hr	
A109	TK-23-1 tank volume:	2,400 L or	634 gal
A110	TK-25-2 tank volume:	15,140 L or	4,000 gal
A111	Lag storage between IX and E-23-3	45,420 L	12,000 gal
A112	Time to transfer TK-25-2 out;	2 hr	

#### Product Criteria: Glass

A113	Waste Loading, wt.waste oxides/glass wt.	0.25 fraction
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## APPENDIX 2

Assumptions for 20 Vol% Settled Solids Feed  
Table A-1, Material Balance - Mol/L Basis  
(20 Vol% SS Feed)  
Table A-2, Material Balance - MTU Basis  
(20 Vol% SS Feed)

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ASSUMPTIONS (A# is the assumption number referenced in calculations)  
For 20 vol% Settled Solids Feed

Input Stream from AR Vault

A1 Input stream :The components represent the blend in TK-101-AZ,  
the data is from Ltrs 65611-86-039 and -151

A2 Input Stream Volume: 1,453 L/MTU, or 384 gal/MTU  
A3 Batch from AR Vault: 52,990 L, or 14,000 gal  
A4 Solids content: 3.5 wgt% or 35,000 ppm  
A5 Settled Solids volume: 20 % of feed slurry  
A6 Overall Density 1.2 g/cc  
A7 Settled Solids Density 1.25 g/cc  
A8 TK-101-AZ solids: 3.5 wgt%

A9 Input Stream Composition (adjusted for low solids if necessary):  
(Selected components from Table 3-2 below. See Table 3-2 for  
assumed washing behaviour)

Component	B Plant Feed mol/MTU	GMW	
OH-	1,453	17.01	
F-	126	19.00	
NO2-	625	46.01	
NO3-	2,471	62.01	
SO4-2	218	96.06	
CO3-2	334	60.01	
Na+	7,267	22.99	
Al	727	26.98	
Cr	17.4	52.00	
Fe+3	97	55.84	
Sr	0.61	87.62	
Zr	64	91.22	
Cs	0.64	134.90	137 Cs137
K	174		
Rb	0.16		
Misc. solids	1.00		
Misc. solubles	1.00		
U	5.7	238.00	
TOC	2,471 g/MTU	12.00	
Pu	3.77 g/MTU	239.00	
Am	3.73 g/MTU	241.00	
Np	16.70 g/MTU	237.00	
90Sr/Y	3,388 Ci/MTU		
137Cs/Ba	2,883 Ci/MTU		
106Ru/Rh	72 Ci/MTU		
144Ce/Pr	254 Ci/MTU		

There are a number of other components of interest in the  
NCAW stream. All components are tracked by using the 1 mol/MTU  
of miscellaneous solid and soluble components in each stream,  
which are followed in this spreadsheet (chem additions are also  
accounted for where necessary).

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#### Water Flush Addition Volumes to Process Tanks

A10	Standard Flush	379	L/batch	100 gal/batch
A11	TK-25-1 Flush to Tank Farms	10,068	L/batch	2,660 gal/batch
A12	TK-12-1 Flush to AR Vault	10,068	L/batch	2,660 gal/batch

#### B Plant Facility Parameters

A13	Batch Volume from AR Vault	58,403	L/batch	15,430 gal/batch
A14	Jet Capacity	17,033	L/hr	75 gal/min
A15	Jet rate for decantation	5,678	L/hr	25 gal/min
A16	Typical Pumping rate	17,033	L/hr	75 gal/min
A17	Scale Tank Addition Rate	6,813	L/hr	30 gal/min
A18	Jet Dilution - Liquids			1.03 ratio
A19	Jet Dilution - Solid Slurries			1.05 ratio
A20	Total Operating Efficiency			59 % TOE

#### TRU Isotopic Data - for the mix of fuel in tank 101AZ

A21	Am241 activity	3.43 Ci/g
A22	Pu Alpha Activity	0.098 Ci/g w/max Am241 ingrowth

#### Grout Parameters

A23	Ratio Grout Volume to Feed Volume:	1.3 :1
A24	Grout Density:	1.4 g/cc

#### Chemical Additions to Process Tanks

A25	Required OH- Molarity in DST	0.02 mol/L
A26	Required NO2- Molarity in DST	0.02 mol/L
A27	NaOH essential materials (EM) conc.	19 mol/L
A28	Minimum chem addition volume	380 L
A29	NaNO2 EM concentration	2.5 mol/L
A30	HNO3 EM concentration	12.2 mol/L

#### Settle/Decant Assumptions

A31	Decant jet height above SS;	0.23 m or	1,068 L
A32	SS level at rate transition :	30 % greater than final vol%	
A33	Interstitial liquor in SS;	80 volume%	
A34	Primary Tank Volume;	15,519 L	
A35	First wash tank effective volume;	15,519 L considering 1 jet diln	
A36	Second wash tank effective volume;	15,519 L considering 2 jet dilns	
A37	Solids in primary decant;	300 ppm	
A38	Solids in wash decants;	300 ppm	
A39	1st wash ratio:	3 :1 water:primary tank SS	
A40	2nd wash ratio:	3 :1 water:primary tank SS	
A41	Maximum solids for pumpability;	30.0 vol% SS	
A42	TK-25-1 tank volume;	14,800 L	
A43	Slurry batches in TK-25-1;	1	
A44	Density 2nd wash solids slurry;	1.07 g/cc	

#### Ferric Nitrate Add

A45	Ferric Nitrate addition:	200 ppm
A46	Molecular weight;	407 as a nonhydrate

#### Time Cycle Assumptions for settle/decant

A47	Settling Rate For Primary Tank:	5.0 cm/hr
A48	Settling Rate For Wash Tank:	10.2 cm/hr
A49	Agitate/Slurry Time:	2 hr
A50	Settling Tank Radius:	1.22 m

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A51 Head Required to Jet: 1,890 L

Inverted PHP Filter Assumptions:

A52 Filter size; 6.51 sq m surface area  
A53 Filter/Backflush volume; 130 L  
A54 Precoat amount; 452 g/sq m/cycle  
A55 Body feed addition; 0.25 : 1 DE to solids  
A56 Agitation Of Body Feed: 0.5 hr  
A57 Time for backflush cycle; 0.083 hr/cycle  
A58 Precoat addition volume; 1,136 L/cycle  
A59 Body Feed Addition Volume: 379 L/cycle  
A60 Filtrate clarity (average); 10 ppm in filtrate  
A61 Feed Rate (filtrate rate); 4,542 L/hr, 0.29 g/min/sq ft  
A62 Cell 9/30 to Cell 7/8 rates; 0.75 ratio  
A63 Lag storage between PHP and IX; 45,647 L

Diatomaceous Earth (DE) composition (SiO<sub>2</sub> is balance)

A64 Component Weight %  
Na<sub>2</sub>O 0.55  
Al<sub>2</sub>O<sub>3</sub> 4  
Fe<sub>2</sub>O<sub>3</sub> 1.3  
Misc. 2.55

Ion Exchange Assumptions:

A65 Plug flow conditions except for the ions which are exchanged  
A66 Feed rate: 6,813 L/hr or 30 gpm  
A67 Column volume: 6,624 L or 1,750 gallons  
A68 Bed (resin void) volume: 3,709 L or 980 gallons  
A69 S/D cycles to match PHP & IX 2 S/D cycles  
A70 Vol. Limit, 2nd cycle feed: 14,023 L  
A71 Cs-137 specific activity: 86.6 Ci/g  
A72 Cs-137 / Cesium mol ratio: 0.38 Cs137/Cs

Component Splits in Ion Exchange Streams

Percentages for Rb are assumed to be the same as for Cs  
(percent of component in ion exchange feed stream)

A73 First IX Cycle

Component	Loading Waste & Flush	Sodium Scrub	Cesium Elution & Flush
Cs	2.35	0.39	97.26
Na	97.11	1.84	1.06
Al	99.17	0.6	0.22
K	90.0	5.0	5.0

A74 Second IX Cycle

Component	Loading Waste & Flush	Sodium Scrub	Cesium Elution & Flush
Cs	1.84	1.43	96.73
Na	90.4	5.18	4.42
Al	1.3	27.04	71.7
K	90.0	5.0	5.0

A75 Required OH<sup>-</sup> to feed 2nd IX cycle: 0.1 molar

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A76	Feed flush volume, 1st cycle:	2 col volumes/batch
A77	Feed flush volume, 2nd cycle:	2 col volumes/batch
A78	Sodium scrub composition:	0.1 Molar HNO <sub>3</sub>
A79	Sodium scrub volume, 1st cycle:	8.5 col volumes/batch
A80	Sodium scrub volume, 2nd cycle:	5.5 col volumes/batch
A81	1st cycle Cs elution composition:	0.3 Molar HNO <sub>3</sub>
A82	2nd cycle Cs elution composition:	0.5 Molar HNO <sub>3</sub>
A83	Cesium elution volume, 1st cycle:	8 col volumes/batch
A84	Cesium elution volume, 2nd cycle:	6 col volumes/batch
A85	Eluent flush volume:	4 col volumes/batch
Regeneration volume and composition (NaOH):		
A86	1st stage:	0.5 mol/L 1 col volumes/batch
A87	2nd, 1st cycle;	2.0 mol/L 2 col volumes/batch
A88	2nd, 2nd cycle;	2.0 mol/L 2 col volumes/batch
A89	Regeneration flush volume:	1 col volumes/batch

#### Concentrator Assumptions

A90	LLW and 2nd Cs eluent are concentrated to:	5 mol/L Na	
A91	1st IX cycle Cs eluent is concentrated to:	2.5 mol/L Na	
A92	Start-up molarity in E-23-3 after flushed:	2 mol/L Na	
A93	Start-up molarity in E-20-2 after emptied:	0 mol/L Na	
A94	HNO <sub>3</sub> start-up molarity in E-20-2:	4.2 mol/L HNO <sub>3</sub>	
A95	Nitric acid recovery, 1st IX cycle:	100 %	
A96	Nitric acid recovery, 2nd IX cycle:	100 %	
A97	Deentrainer water add for E-23-3:	1,136 L/hr	
A98	Flush to T-18-2 to send eluant to TK-19-1;	7,570 L or	2000 gal
A99	Feed rate to E-23-3 during buildup:	6,813 L/hr or	30 gpm
A100	Feed rate to E-20-2:	1,817 L/hr or	8 gpm
A101	Volume for pump head:	3,785 L	
A102	Start-up time for concentrator:	1 hr	
A103	Feed rate to E-23-3 during overflow;	12,491 L/hr or	55 gpm
A104	Overhead boil off rate from E-23-3 concen;	7,949 L/hr or	35 gpm
A105	Pot volume in E-20-2:	757 L or	200 gal
A106	Pot volume in E-23-3:	7,570 L or	2,000 gal
A107	Volume overflowed from E-23-3 concen;	1,893 L or	500 gal
A108	Time to cool E-20-2 before jetting;	1 hr	
A109	TK-23-1 tank volume:	2,400 L or	634 gal
A110	TK-25-2 tank volume:	15,140 L or	4,000 gal
A111	Lag storage between IX and E-23-3	45,420 L	12,000 gal
A112	Time to transfer TK-25-2 out;	2 hr	

#### Product Criteria: Glass

A113	Waste Loading, wt.waste oxides/glass wt.	0.25 fraction
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Table A-1  
Material Balance Table  
20 vol% Settled Solids Feed

Component	Stream Numbers -->>>									
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
(mol/L)										
OH-	1 0E+00	9 5E-01			2 3E-02		8 8E-03			1 1E-01
F-	8 7E-02	8 3E-02			2 0E-03		7 7E-04			9 7E-03
NO2-	4 3E-01	4 1E-01			1 0E-02		3 8E-03			4 8E-02
NO3-	1 7E+00	1 6E+00		2 0E-02	4 0E-02		1 5E-02			1 9E-01
SO4-2	1 5E-01	1 4E-01			3 5E-03		1 3E-03			1 7E-02
CO3-2	2 3E-01	2 2E-01			5 4E-03		2 0E-03			2 6E-02
Na+	5 0E+00	4 8E+00			1 2E-01		4 4E-02			5 6E-01
Al	5 0E-01	4 8E-01			1 1E-02		5 1E-02			5 2E-02
Cr	1 2E-02	1 1E-02			2 7E-04		1 2E-03			1 3E-03
Fe+3	6 7E-02	6 4E-02		2 0E-02	5 9E-04		8 9E-02			5 9E-04
Sr	4 2E-04	4 0E-04			3 7E-06		5 6E-04			3 7E-06
Zr	4 4E-02	4 2E-02			3 8E-04		5 8E-02			3 9E-04
Cs	4 4E-04	4 2E-04			1 0E-05		3 9E-06			4 9E-05
K	1 2E-01	1 1E-01			2 8E-03		1 1E-03			1 3E-02
Rb	1 1E-04	1 0E-04			2 6E-06		9 7E-07			1 2E-05
U	3 9E-02	3 8E-03			3 4E-05		5 2E-03			3 5E-05
(g/L)										
TDC	1 7E+00	1 6E+00			2 3E-02		1 5E+00			7 3E-02
Pu	2 6E-03	2 5E-03			2 3E-05		3 4E-03			2 3E-05
Am	2 6E-03	2 4E-03			2 2E-05		3 4E-03			2 3E-05
Np	1 1E-02	1 1E-02			1 0E-04		1 5E-02			1 0E-04
Diat. Earth (OE)										
Isotopes Decayed to 10/1/90, (Ci/L)										
90Sr/Y	2 3E+00	2 2E+00			2 0E-02		8 1E+00			2 1E-02
137Cs/Ba	2 0E+00	1 9E+00			4 6E-02		1 8E-02			2 2E-01
106Ru/Rh	5 0E-02	4 7E-02			8 0E-04		9 3E-02			3 0E-03
144Ce/Pr	1 7E-01	1 7E-01			1 5E-03		2 3E-01			1 5E-03
Volume (L)	45,978	13,137	10,068	880	12,178	5,063	9,196	379	390	12,178
(gal)	12,147	3,471	2,660	100	3,218	1,338	2,429	100	103	3,218

Table A-1  
Material Balance Table  
20 vol% Settled Solids Feed

Component	S11	S12	S13	S14	S15	S16	S17	S18	S19	S20
(mol/L)										
OH-	1.1E-01		2.4E-02	1.1E+00		1.1E-01	6.5E-02	4.5E-02		7.7E-01
F-	9.5E-03		2.0E-03	9.3E-02		9.7E-03	5.6E-03	3.9E-03		
NO2-	4.7E-02		1.0E-02	4.6E-01		4.8E-02	2.8E-02	1.9E-02	9.6E-01	
NO3-	1.8E-01		4.0E-02	1.8E+00		1.9E-01	1.1E-01	7.6E-02		
SO4--2	1.6E-02		3.3E-03	1.6E-01		1.7E-02	9.7E-03	6.7E-03		
CO3--2	2.5E-02		5.4E-03	2.5E-01		2.6E-02	1.5E-02	1.0E-02		
Na+	5.4E-01		1.2E-01	5.3E+00		5.6E-01	3.2E-01	2.2E-01	9.6E-01	7.7E-01
Al	5.1E-02		3.9E-02	5.0E-01		8.0E-02	3.0E-02	2.1E-02		
Cr	1.2E-03		5.9E-04	1.2E-02		1.9E-03	7.3E-04	5.1E-04		
Fe+3	5.7E-04		5.3E-02	7.1E-04		5.4E-02	5.6E-04	3.9E-04		
Sr	3.6E-06		3.3E-04	4.5E-06		3.4E-04	3.5E-06	2.4E-06		
Zr	3.8E-04		3.5E-02	4.7E-04		3.5E-02	3.7E-04	2.6E-04		
Cs	4.8E-05		1.0E-05	4.7E-04		4.9E-05	2.8E-05	2.0E-05		
K	1.3E-02		2.8E-03	1.3E-01		1.3E-02	7.8E-03	5.4E-03		
Hb	1.2E-05		2.6E-06	1.2E-04		1.2E-05	7.1E-06	4.9E-06		
U	3.4E-05		3.1E-03	4.2E-05		3.2E-03	3.8E-05	2.9E-05		
(g/L)										
TOC	7.1E-02		9.2E-01	6.1E-01		9.7E-01	4.6E-02	3.2E-02		
Pu	2.2E-05		2.1E-03	2.7E-05		2.1E-03	2.2E-05	1.5E-05		
Am	2.2E-05		2.0E-03	2.7E-05		2.1E-03	2.2E-05	1.5E-05		
Np	9.8E-05		9.1E-03	1.2E-04		9.2E-03	9.6E-05	6.7E-05		
Diat. Earth (DE)										
Isotopes Decayed to 10/1/90, (Ci/L)										
90Sr/Y	2.0E-02		1.8E+00	2.5E-02		1.9E+00	2.0E-02	1.4E-02		
137Cs/Ba	2.2E-01		4.7E-02	2.1E+00		2.2E-01	1.3E-01	8.9E-02		
106Ru/Rh	2.9E-03		2.0E-02	2.7E-02		2.3E-02	1.8E-03	1.3E-03		
144Ce/Pr	1.5E-03		1.4E-01	1.9E-03		1.4E-01	1.5E-03	1.0E-03		
Volume (L)	12,544	11,085	15,519	10,116	11,085	15,519	25,464	36,647	880	880
(gall)	3,314	2,929	4,100	2,673	2,929	4,100	6,728	9,682	100	100

Table A-1.  
Material Balance Table  
20 vol% Settled Solids Feed

Component	S21.	S22.	S23.	P1.	P2.	P3.	P4.	P5.	P6.	P7.
(mol/L)										
OH-	3.8E-02			4.4E-02	4.2E-02	4.1E-02			4.1E-02	3.0E-01
F-	1.0E-03			3.8E-03	3.7E-03	3.6E-03			3.5E-03	2.6E-02
NO2-	3.8E-02			1.9E-02	1.8E-02	1.8E-02			1.8E-02	1.3E-01
NO3-	2.0E-02			7.4E-02	7.2E-02	7.0E-02			6.9E-02	5.1E-01
SO4-2	1.7E-03			6.6E-03	6.4E-03	6.2E-03			6.1E-03	4.5E-02
CO3-2	2.7E-03			1.0E-02	9.8E-03	9.5E-03			9.4E-03	6.8E-02
Na+	1.2E-01			2.2E-01	2.1E-01	2.1E-01			2.0E-01	1.5E+00
Al	4.5E-02			2.1E-02	2.0E-02	1.9E-02			1.9E-02	1.4E-01
Cr	1.3E-03			4.9E-04	4.8E-04	4.6E-04			4.6E-04	3.3E-03
Fe+3	7.7E-02			3.8E-04	3.7E-04	3.6E-04			3.5E-04	1.7E-05
Sr	4.8E-04			2.4E-06	2.3E-06	2.2E-06			2.2E-06	1.1E-07
Zr	5.0E-02			2.5E-04	2.4E-04	2.3E-04			2.3E-04	1.1E-03
Cs	5.1E-06			1.9E-05	1.9E-05	1.8E-05			1.8E-05	1.3E-04
K	1.4E-03			5.2E-03	5.1E-03	4.9E-03			4.9E-03	3.6E-02
Rb	1.3E-06			4.8E-06	4.7E-06	4.5E-06			4.5E-06	3.3E-03
U	4.5E-03			2.2E-05	2.2E-05	2.1E-05			2.1E-05	1.0E-06
(g/L)										
TDC	1.3E+00			3.1E-02	3.0E-02	2.9E-02			2.9E-02	1.7E-01
Pu	3.0E-03			1.5E-05	1.4E-05	1.4E-05			1.4E-05	6.7E-07
Am	2.9E-03			1.5E-05	1.4E-05	1.4E-05			1.4E-05	6.6E-07
Np	1.3E-02			6.5E-05	6.3E-05	6.1E-05			6.1E-05	3.0E-06
Diat. Earth (DE)	4.7E-01			0.0E+00	0.0E+00	0.0E+00	2.6E+00	4.5E+00	1.3E-01	4.2E-03
Isotopes Decayed to 10/1/90, (Ci/L)										
90Sr/Y	2.7E+00			1.3E-02	1.3E-02	1.2E-02			1.2E-02	6.0E-04
137Cs/Ba	2.9E-02			8.7E-02	8.4E-02	8.2E-02			8.1E-02	5.9E-01
106Ru/Rh	2.9E-02			1.2E-03	1.2E-03	1.2E-03			1.1E-03	7.4E-03
144Ce/Pr	2.0E-01			9.9E-04	9.6E-04	9.3E-04			9.2E-04	4.5E-03
Volume (L)	10,947	10,068	10,068	75,494	34,019	35,040	1,136	379	35,418	36,424
(gal)	2,892	2,660	2,660	19,945	8,988	9,258	300	100	9,358	9,628

Table A-1.  
Material Balance Table  
20 vol% Settled Solids Feed

Component	P8.	P9.	P10.	P11.	X1.	X2.	X3.	X4.	X5.	X6.
(mol/L)										
OH-	3.1E-01	3.0E-01	2.8E-01	2.7E-01	2.9E-01	2.9E-01	2.8E-01	2.8E-01	2.7E-01	
F-	2.7E-02	2.6E-02	2.4E-02	2.3E-02	2.5E-02	2.5E-02	2.4E-02	2.4E-02	2.4E-02	
NO2-	1.9E-01	1.9E-01	1.8E-01	1.2E-01	1.2E-01	1.2E-01	1.2E-01	1.2E-01	1.2E-01	
NO3-	5.3E-01	5.0E-01	4.8E-01	4.6E-01	4.9E-01	4.9E-01	4.8E-01	4.8E-01	4.7E-01	
SO4-2	4.7E-02	4.4E-02	4.2E-02	4.0E-02	4.3E-02	4.3E-02	4.2E-02	4.2E-02	4.1E-02	
CO3-2	7.1E-02	6.8E-02	6.5E-02	6.2E-02	6.6E-02	6.6E-02	6.4E-02	6.4E-02	6.3E-02	
Na+	1.6E+00	1.5E+00	1.4E+00	1.3E+00	1.4E+00	1.4E+00	1.4E+00	1.4E+00	1.3E+00	
Al	2.2E-01	2.1E-01	2.0E-01	1.9E-01	1.3E-01	1.3E-01	1.3E-01	1.3E-01	1.3E-01	
Cr	5.2E-03	5.0E-03	4.7E-03	4.5E-03	3.2E-03	3.2E-03	3.1E-03	3.1E-03	3.1E-03	
Fe+3	1.4E-01	1.3E-01	1.3E-01	1.2E-01	1.7E-05	1.7E-05	1.6E-05	1.6E-05	1.6E-05	
Sr	8.8E-04	8.3E-04	8.0E-04	7.6E-04	1.0E-07	1.0E-07	1.0E-07	1.0E-07	9.9E-08	
Zr	9.2E-02	8.7E-02	8.3E-02	7.9E-02	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	
Cs	1.4E-04	1.3E-04	1.2E-04	1.2E-04	1.3E-04	1.3E-04	1.2E-04	1.2E-04	2.8E-06	
K	3.7E-02	3.5E-02	3.4E-02	3.2E-02	3.5E-02	3.5E-02	3.4E-02	3.4E-02	3.0E-02	
Rb	3.4E-05	3.3E-05	3.1E-05	2.9E-05	3.2E-05	3.2E-05	3.1E-05	3.1E-05	7.1E-07	
U	8.2E-03	7.9E-03	7.5E-03	7.1E-03	9.8E-07	9.8E-07	9.6E-07	9.6E-07	9.3E-07	
(g/L)										
TOC	2.6E+00	2.4E+00	2.3E+00	2.2E+00	1.6E-01	1.6E-01	1.6E-01	1.6E-01	1.5E-01	
Pu	5.4E-03	5.2E-03	4.9E-03	4.7E-03	6.5E-07	6.5E-07	6.3E-07	6.3E-07	6.1E-07	
Am	5.4E-03	5.1E-03	4.9E-03	4.6E-03	6.4E-07	6.4E-07	6.2E-07	6.2E-07	6.1E-07	
Np	2.4E-02	2.3E-02	2.2E-02	2.1E-02	2.9E-06	2.9E-06	2.8E-06	2.8E-06	2.7E-06	
Diat. Earth (DE)	3.4E+01	3.3E+01	3.1E+01	3.0E+01	4.1E-03	4.1E-03	4.0E-03	4.0E-03	3.9E-03	
Isotopes Decayed to 10/1/90, (Ci/L)										
90Sr/Y	4.9E+00	4.6E+00	4.4E+00	4.2E+00	5.8E-04	5.8E-04	5.6E-04	5.6E-04	5.5E-04	
137Cs/Ba	6.2E-01	5.9E-01	5.6E-01	5.3E-01	5.7E-01	5.7E-01	5.6E-01	5.6E-01	1.3E-02	
106Ru/Rh	6.0E-02	5.7E-02	5.4E-02	5.2E-02	7.2E-03	7.2E-03	7.0E-03	7.0E-03	6.8E-03	
144Ce/Pr	3.6E-01	3.5E-01	3.3E-01	3.1E-01	4.4E-03	4.4E-03	4.2E-03	4.2E-03	4.1E-03	
Volume (L)	190	410	430	451	37,517	37,517	38,642	154,569	154,569	13,248
(gal)	34	108	114	119	9,912	9,912	10,209	40,837	40,837	3,500

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Table A-1  
Material Balance Table  
20 vol% Settled Solids Feed

Component	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16
(mol/L)										
OH-	7.9E-02			1.9E+01						1.0E+00
F-	6.8E-08									
NO2-	3.4E-02									
NO3-	1.8E-01	1.0E-01	9.3E-02		3.0E-01	2.9E-01		1.5E-01		
SO4-2	1.2E-02									
CO3-2	1.8E-02									
Na+	8.8E-01		7.1E-02	1.9E+01		4.0E-02		2.1E-02		1.0E+00
Al	3.6E-02		2.1E-03			7.8E-04		4.1E-04		
Cr	8.8E-04									
Fe+3	4.5E-06									
Sr	2.8E-08									
Zr	3.0E-06									
Cs	8.1E-07		1.3E-06			3.2E-04		1.7E-04		
K	8.5E-03		4.6E-03			4.6E-03		2.4E-03		
Rb	2.0E-07		3.3E-07			8.1E-05		4.3E-05		
U	2.7E-07									
(g/L)										
TDC	4.4E-02									
Pu	1.8E-07									
Am	1.7E-07									
Np	7.8E-07									
Diat. Earth (DE)	1.1E-03									
Isotopes Decayed to 10/1/90, (Ci/L)										
90Sr/Y	1.6E-04									
137Cs/Ba	3.7E-03		6.0E-03			1.5E+00		7.7E-01		
106Ru/Rh	2.0E-03									
144Ce/Pr	1.2E-05									
Volume (L)	13,248	56,302	56,302	343	52,990	52,990	26,495	7,570	18,925	19,871
(gall)	3,500	14,875	14,875	91	14,000	14,000	7,000	2,000	5,000	5,250

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Table A-1.  
Material Balance Table  
20 vol% Settled Solids Feed

Component	X17.	X18.	X19.	X20.	X21.	X22.	X23.	X24.	X25.	X26.
(mol/L)										
OH-	1.1E+00		1.1E+00	2.9E-01						
F-				1.4E-02						
NO2-				6.9E-02						
NO3-				2.9E-01		2.7E-01	2.8E-01	1.2E+01	6.3E+00	6.1E+00
SO4-2				2.4E-02						
CO3-2				3.7E-02						
Na+	1.1E+00		1.1E+00	9.3E-01		3.8E-02			2.5E+00	2.4E+00
Al				7.5E-02		7.3E-04			4.8E-02	4.7E-02
Cr				1.8E-03						
Fe+3				9.3E-06						
Sr				5.8E-08						
Zr				6.1E-06						
Cs				1.9E-06		3.0E-04			2.0E-02	1.9E-02
K				1.8E-02		4.3E-03			2.8E-01	2.7E-01
Rb				4.8E-07		7.7E-05			5.0E-03	4.9E-03
U				6.3E-04						
(g/L)										
TOC				9.0E-02						
Pu				3.6E-07						
Am				3.6E-07						
Np				1.6E-06						
Diat. Earth (DE)				2.3E-03						
Isotopes Decayed to 10/1/90, (Ci/L)										
90Sr/Y				3.2E-04						
137Cs/Ba				8.7E-03		1.4E+00			9.1E+01	8.8E+01
106Ru/Rh				4.0E-03						
144Ce/Pr				2.4E-05						
Volume (L)	19,871	6,624	6,624	269,881	757	60,560	60,398	185	919	946
(gal)	5,250	1,750	1,750	71,303	200	16,000	15,957	49	243	250

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Table A-1.  
Material Balance Table  
20 vol% Settled Solids Feed

Component	C1.	C2.	C3.	C4.	C5.	C6.	C7.	C8.	C9.	C10.
(mol/L)										
DH-	8.7E+00	9.7E-02	9.7E-02	9.4E-02	9.4E-02	6.7E-02		2.6E-02		
F-										
NO2-										
NO3-		4.2E+00	4.2E+00	4.1E+00	4.1E+00	2.9E+00		1.2E+00		9.0E-02
SO4-2										
CO3-2										
Na+	8.7E+00	4.1E+00	4.1E+00	4.0E+00	4.0E+00	2.6E+00		7.3E-01		7.2E-02
Al		3.2E-02	3.2E-02	3.2E-02	3.2E-02	2.9E-04		1.1E-04		3.0E-08
Cr										
Fe+3										
Sr										
Zr										
Cs		1.4E-02	1.4E-02	1.3E-02	1.3E-02	1.7E-04		6.8E-03		6.5E-03
K		1.9E-01	1.9E-01	1.8E-01	1.8E-01	1.2E-01		4.7E-02		3.2E-08
Rb		3.4E-03	3.4E-03	3.3E-03	3.3E-03	4.3E-03		1.7E-03		1.6E-03
U										
(g/L)										
TOC										
Pu										
Am										
Np										
Diat. Earth (DE)										
Isotopes Decayed to 10/1/90, (Ci/L)										
90Sr/Y										
137Cs/Ba		6.1E+01	6.1E+01	5.9E+01	5.9E+01	7.7E-01		3.1E-01		3.0E-01
106Ru/Rh										
144Ce/Pr										
Volume (L)	380	1,366	1,366	1,407	12,665	12,665	13,248	18,248	36,431	36,481
(gal)	100	361	361	372	3,346	3,346	3,500	3,500	9,625	9,625

Table A-1.  
Material Balance Table  
20 vol% Settled Solids Feed

Component	C11.	C12.	C13.	C14.	C15.	C16.	C17.	C18.	C19.	C20.
(mol/L)										
OH-	1.1E+01						1.5E+00	1.1E+00		1.1E+00
F-										
NO2-										
NO3-		5.0E-01	4.6E-01		2.4E-01					
SO4-2										
CO3-2										
Na+	1.1E+01		4.7E-02		4.9E-02		1.5E+00	1.1E+00		1.1E+00
Al			6.0E-03		6.3E-03					
Cr										
Fe+3										
Sr										
Zr										
Cs			3.4E-03		3.5E-03					
K			2.5E-03		2.6E-03					
Rb			8.5E-04		8.9E-04					
U										
(g/L)										
TOC										
Pu										
Am										
Np										
Diat. Earth (DE)										
Isotopes Decayed to 10/1/90, (Ci/L)										
90Sr/Y										
137Cs/Ba			1.5E+01		1.6E+01					
106Ru/Rh										
144Ce/Pr										
Volume (L)	880	39,743	39,743	26,495	7,570	18,925	19,871	19,871	6,624	6,624
(gal)	100	10,500	10,500	7,000	2,000	5,000	5,250	5,250	1,750	1,750

Table A-1.  
Material Balance Table  
20 vol% Settled Solids Feed

Component	C21	C22	C23	C24	C25	C26	C27	C28	C29	C30
(mol/L)										
OH-	3.2E-01								2.9E-01	
F-									1.3E-02	
NO2-									6.6E-02	
NO3-	5.1E-01	4.2E+00	4.3E-01	3.7E-01	2.7E+02	1.3E+01	1.3E+01	1.3E+01	3.0E-01	
SO4-2									2.3E-02	
CO3-2									3.5E-02	
Na+	7.2E-01		4.7E-02			5.0E+00	4.9E+00	4.7E+00	9.2E-01	
Al	1.0E-09		6.0E-03			6.4E-01	6.2E-01	6.0E-01	7.1E-02	
Cr									1.7E-03	
Fe+3									8.9E-06	
Sr									5.6E-08	
Zr									5.8E-06	
Cs	5.0E-05		3.4E-03			3.6E-01	3.5E-01	3.4E-01	4.0E-06	
K	2.1E-02		2.5E-03			2.6E-01	2.5E-01	2.5E-01	1.8E-02	
Rb	1.3E-03		8.5E-04			9.0E-02	8.8E-02	8.5E-02	1.0E-06	
U									5.2E-07	
(g/L)										
TOC									8.6E-02	
Pu									3.4E-07	
Am									3.4E-07	
Np									1.5E-06	
Diat. Earth (DE)									2.2E-03	
Isotopes Decayed to 10/1/90, (Ci/L)										
90Sr/Y									3.1E-04	
137Cs/Ba	2.3E-01		1.5E+01			1.6E+03	1.6E+03	1.5E+03	1.8E-02	
106Ru/Rh									3.8E-03	
144Ce/Pr									2.9E-05	
Volume (L)	108,149	757	47,913	47,623	202	446	460	473	378,024	5,616
(gal)	28,571	200	12,500	12,582	53	118	121	125	99,874	1,484

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Table A-1.  
Material Balance Table  
20 vol% Settled Solids Feed

Component	C91.	C92.	C93.	C94.
(mol/L)				
OH-	1.6E+00	1.6E+00	1.6E+00	
F-	7.3E-02	7.3E-02	7.3E-02	
NO2-	3.6E-01	3.6E-01	3.6E-01	
NO3-	1.6E+00	1.6E+00	1.6E+00	
SO4-2	1.3E-01	1.3E-01	1.3E-01	
CO3-2	1.9E-01	1.9E-01	1.9E-01	
Na+	5.0E+00	5.0E+00	5.0E+00	
Al	3.9E-01	3.9E-01	3.9E-01	
Cr	9.3E-03	9.3E-03	9.3E-03	
Fe+3	4.8E-05	4.8E-05	4.8E-05	
Sr	3.0E-07	3.0E-07	3.0E-07	
Zr	3.2E-05	3.2E-05	3.2E-05	
Cs	2.2E-05	2.2E-05	2.2E-05	
K	1.0E-01	1.0E-01	1.0E-01	
Rb	5.4E-06	5.4E-06	5.4E-06	
U	2.8E-06	2.8E-06	2.8E-06	
(g/L)				
TOC	4.7E-01	4.7E-01	4.7E-01	
Pu	1.9E-06	1.9E-06	1.9E-06	
Am	1.9E-06	1.9E-06	1.9E-06	
Np	8.3E-06	8.3E-06	8.3E-06	
Diat. Earth (DE)	1.2E-02	1.2E-02	1.2E-02	
Isotopes Decayed to 10/1/90, (Ci/L)				
90Sr/Y	1.7E-03	1.7E-03	1.7E-03	
137Cs/Ba	9.8E-02	9.8E-02	9.8E-02	
106Ru/Rh	2.1E-02	2.1E-02	2.1E-02	
144Ce/Pr	1.3E-04	1.3E-04	1.3E-04	
Volume (L)	314,056	69,384	69,384	69,384
(gall)	82,974	18,384	18,384	18,384

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Table A-2. MTU Basis  
Material Balance Table  
20 vol% Settled Solids Feed

Component	Stream Numbers -->>>									
	S1.	S2.	S3	S4	S5	S6	S7.	S8.	S9	S10
(mol/MTU)										
OH-	1.5E+08	1.5E+03			3.8E+01		9.4E+00			1.6E+02
F-	1.3E+02	1.3E+02			2.9E+00		8.2E-01			1.4E+01
NO2-	6.2E+02	6.2E+02			1.4E+01		4.1E+00			6.8E+01
NO3-	2.5E+03	2.5E+03		8.7E-01	5.6E+01		1.6E+01			2.7E+02
SO4-2	2.2E+02	2.2E+02			5.0E+00		1.4E+00			2.4E+01
CO3-2	3.3E+02	3.3E+02			7.6E+00		2.2E+00			3.6E+01
Na+	7.3E+03	7.3E+03			1.7E+02		4.7E+01			7.9E+02
Al	7.3E+02	7.3E+02			1.6E+01		5.4E+01			7.4E+01
Cr	1.7E+01	1.7E+01			3.8E-01		1.3E+00			1.8E+00
Fe+3	9.7E+01	9.7E+01		8.7E-01	8.3E-01		9.5E+01			8.3E-01
Br	6.1E-01	6.1E-01			5.2E-03		5.9E-01			5.2E-03
Zr	6.4E+01	6.4E+01			5.4E-01		6.2E+01			5.5E-01
Ce	6.4E-01	6.4E-01			1.4E-02		4.1E-03			6.9E-02
K	1.7E+02	1.7E+02			4.0E+00		1.1E+00			1.9E+01
Rb	1.6E-01	1.6E-01			3.6E-03		1.0E-03			1.7E-02
U	5.7E+00	5.7E+00			4.9E-02		5.6E+00			4.9E-02
(g/MTU)										
TOC	2.5E+03	2.5E+03			3.3E+01		1.6E+03			1.0E+02
Pu	3.8E+00	3.8E+00			3.2E-02		3.7E+00			3.2E-02
Am	3.7E+00	3.7E+00			3.2E-02		3.6E+00			3.2E-02
Np	1.7E+01	1.7E+01			1.4E-01		1.6E+01			1.4E-01
Diat. Earth (DE)										
Isotopes decayed to 10/1/90, (Ci/MTU)										
90Sr/Y	3.4E+03	3.4E+03			2.9E+01		3.3E+03			2.9E+01
137Cs/Ba	2.9E+03	2.9E+03			6.6E+01		1.9E+01			3.1E+02
106Ru/Rh	7.2E+01	7.2E+01			1.1E+00		3.6E+01			4.3E+00
144Ce/Pr	2.5E+02	2.5E+02			2.2E+00		2.5E+02			2.2E+00
MTU/batch	31.6	8.6	31.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6

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Table A-2. MTU Basis  
Material Balance Table  
20 vol% Settled Solids Feed

Component	S11.	S12.	S13.	S14.	S15.	S16.	S17.	S18.	S19.	S20.
(mol/MTU)										
OH-	1.6E+02		4.2E+01	1.3E+03		2.0E+02	1.9E+02	1.9E+02		3.4E+01
F-	1.4E+01		3.7E+00	1.1E+02		1.7E+01	1.7E+01	1.7E+01		
NO2-	6.8E+01		1.8E+01	5.4E+02		8.6E+01	8.2E+01	8.2E+01	4.2E+01	
NO3-	2.7E+02		7.2E+01	2.1E+03		3.4E+02	3.3E+02	3.3E+02		
SO4-2	2.4E+01		6.4E+00	1.9E+02		3.0E+01	2.9E+01	2.9E+01		
CO3-2	3.6E+01		9.8E+00	2.9E+02		4.6E+01	4.4E+01	4.4E+01		
Na+	7.9E+02		2.1E+02	6.3E+03		1.0E+03	9.6E+02	9.6E+02	4.2E+01	3.4E+01
Al	7.4E+01		7.0E+01	5.8E+02		1.4E+02	9.0E+01	9.0E+01		
Cr	1.8E+00		1.7E+00	1.4E+01		3.5E+00	2.2E+00	2.2E+00		
Fe+3	8.3E-01		9.6E+01	8.3E-01		9.7E+01	1.7E+00	1.7E+00		
Sr	5.2E-03		6.0E-01	5.2E-03		6.1E-01	1.0E-02	1.0E-02		
Zr	5.5E-01		6.3E+01	5.5E-01		6.3E+01	1.1E+00	1.1E+00		
Cs	6.9E-02		1.9E-02	5.5E-01		8.8E-02	8.4E-02	8.4E-02		
K	1.9E+01		5.1E+00	1.5E+02		2.4E+01	2.3E+01	2.3E+01		
Rb	1.7E-02		4.7E-03	1.4E-01		2.2E-02	2.1E-02	2.1E-02		
U	4.9E-02		5.6E+00	4.9E-02		5.7E+00	9.8E-02	9.8E-02		
(g/MTU)										
TOC	1.0E+02		1.7E+03	7.2E+02		1.8E+03	1.4E+02	1.4E+02		
Pu	3.2E-02		3.7E+00	3.2E-02		3.7E+00	6.4E-02	6.4E-02		
Am	3.2E-02		3.7E+00	3.2E-02		3.7E+00	6.4E-02	6.4E-02		
Np	1.4E-01		1.6E+01	1.4E-01		1.7E+01	2.9E-01	2.9E-01		
Diat Earth (DE)										
Isotopes decayed to 10/1/90, (Ci/MTU)										
90Sr/Y	2.9E+01		3.3E+03	2.9E+01		3.4E+03	5.8E+01	5.8E+01		
137Cs/Ba	3.1E+02		8.4E+01	2.5E+03		4.0E+02	3.8E+02	3.8E+02		
106Ru/Rh	4.3E+00		3.7E+01	3.2E+01		4.1E+01	5.4E+00	5.4E+00		
144Ce/Pr	2.2E+00		2.5E+02	2.2E+00		2.5E+02	4.8E+00	4.3E+00		
MTU/batch	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6

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Table A-2 MTU Basis  
Material Balance Table  
20 vol% Settled Solids Feed

Component	S21	S22	S23	P1	P2	P3	P4	P5	P6	P7
(mol/MTU)										
OH-	4.9E+01			1.9E+02	1.9E+02	1.9E+02			1.9E+02	1.4E+03
F-	1.3E+00			1.7E+01	1.7E+01	1.7E+01			1.7E+01	1.3E+02
NO2-	4.9E+01			8.2E+01	8.2E+01	8.2E+01			8.2E+01	6.2E+02
NO3-	2.5E+01			3.3E+02	3.3E+02	3.3E+02			3.3E+02	2.4E+03
SO4-2	2.2E+00			2.9E+01	2.9E+01	2.9E+01			2.9E+01	2.2E+02
CO3-2	3.4E+00			4.4E+01	4.4E+01	4.4E+01			4.4E+01	3.3E+02
Na+	1.5E+02			9.6E+02	9.6E+02	9.6E+02			9.6E+02	7.2E+03
Al	5.8E+01			9.0E+01	9.0E+01	9.0E+01			9.0E+01	6.7E+02
Cr	1.6E+00			2.2E+00	2.2E+00	2.2E+00			2.2E+00	1.6E+01
Fe+3	9.8E+01			1.7E+00	1.7E+00	1.7E+00			1.7E+00	8.3E-02
Sr	6.1E-01			1.0E-02	1.0E-02	1.0E-02			1.0E-02	5.2E-04
Zr	6.4E+01			1.1E+00	1.1E+00	1.1E+00			1.1E+00	5.5E-02
Cs	6.5E-03			8.4E-02	8.4E-02	8.4E-02			8.4E-02	6.3E-01
K	1.8E+00			2.3E+01	2.3E+01	2.3E+01			2.3E+01	1.7E+02
Rb	1.6E-03			2.1E-02	2.1E-02	2.1E-02			2.1E-02	1.6E-01
U	5.7E+00			9.8E-02	9.8E-02	9.8E-02			9.8E-02	4.9E-03
(g/MTU)										
TOC	1.7E+03			1.4E+02	1.4E+02	1.4E+02			1.4E+02	8.1E+02
Pu	3.8E+00			6.4E-02	6.4E-02	6.4E-02			6.4E-02	3.2E-03
Am	3.7E+00			6.4E-02	6.4E-02	6.4E-02			6.4E-02	3.2E-03
Np	1.7E+01			2.9E-01	2.9E-01	2.9E-01			2.9E-01	1.4E-02
Diat Earth (DE)	5.9E+02						3.9E+02	2.3E+02	6.2E+02	2.1E+01
Isotopes decayed to 10/1/90, (Ci/MTU)										
90Sr/Y	3.4E+03			5.8E+01	5.8E+01	5.8E+01			5.8E+01	2.9E+00
137Cs/Ba	2.9E+01			3.8E+02	3.8E+02	3.8E+02			3.8E+02	2.9E+03
106Ru/Rh	3.7E+01			5.4E+00	5.4E+00	5.4E+00			5.4E+00	3.6E+01
144Ce/Pr	2.5E+02			4.8E+00	4.3E+00	4.3E+00			4.3E+00	2.2E-01
MTU/batch	8.6	8.6	8.6	17.2	7.5	7.5	7.5	7.5	7.5	7.5

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Table A-2. MTU Basis  
Material Balance Table  
20 vol% Settled Solids Feed

Component	P8.	P9.	P10.	P11.	X1.	X2.	X3.	X4.	X5.	X6.
(mol/MTU)										
OH-	5.4E+00	5.4E+00	5.4E+00	5.4E+00	1.4E+03	1.4E+03	1.4E+03	1.4E+03	1.4E+03	
F-	4.7E-01	4.7E-01	4.7E-01	4.7E-01	1.3E+02	1.3E+02	1.3E+02	1.3E+02	1.3E+02	
NO2-	2.3E+00	2.3E+00	2.3E+00	2.3E+00	6.2E+02	6.2E+02	6.2E+02	6.2E+02	6.2E+02	
NO3-	9.1E+00	9.1E+00	9.1E+00	9.1E+00	2.4E+03	2.4E+03	2.4E+03	2.4E+03	2.4E+03	
SO4-2	8.0E-01	8.0E-01	8.0E-01	8.0E-01	2.2E+02	2.2E+02	2.2E+02	2.2E+02	2.2E+02	
CO3-2	1.2E+00	1.2E+00	1.2E+00	1.2E+00	3.3E+02	3.3E+02	3.3E+02	3.3E+02	3.3E+02	
Na+	2.7E+01	2.7E+01	2.7E+01	2.7E+01	7.2E+03	7.2E+03	7.2E+03	7.2E+03	7.2E+03	
Al	2.8E+00	2.8E+00	2.8E+00	2.8E+00	6.7E+02	6.7E+02	6.7E+02	6.7E+02	6.7E+02	
Cr	9.0E-02	9.0E-02	9.0E-02	9.0E-02	1.6E+01	1.6E+01	1.6E+01	1.6E+01	1.6E+01	
Fe+3	2.4E+00	2.4E+00	2.4E+00	2.4E+00	8.3E-02	8.3E-02	8.3E-02	8.3E-02	8.3E-02	
Sr	1.5E-02	1.5E-02	1.5E-02	1.5E-02	5.2E-04	5.2E-04	5.2E-04	5.2E-04	5.2E-04	
Zr	1.6E+00	1.6E+00	1.6E+00	1.6E+00	5.5E-02	5.5E-02	5.5E-02	5.5E-02	5.5E-02	
Cs	2.3E-03	2.3E-03	2.3E-03	2.3E-03	6.3E-01	6.3E-01	6.3E-01	6.3E-01	6.3E-01	
K	6.4E-01	6.4E-01	6.4E-01	6.4E-01	1.7E+02	1.7E+02	1.7E+02	1.7E+02	1.7E+02	
Rb	5.9E-04	5.9E-04	5.9E-04	5.9E-04	1.6E-01	1.6E-01	1.6E-01	1.6E-01	1.6E-01	
U	1.4E-01	1.4E-01	1.4E-01	1.4E-01	4.9E-03	4.9E-03	4.9E-03	4.9E-03	4.9E-03	
(g/MTU)										
TOC	4.4E+01	4.4E+01	4.4E+01	4.4E+01	8.1E+02	8.1E+02	8.1E+02	8.1E+02	8.1E+02	
Pu	9.3E-02	9.3E-02	9.3E-02	9.3E-02	3.2E-03	3.2E-03	3.2E-03	3.2E-03	3.2E-03	
Am	9.2E-02	9.2E-02	9.2E-02	9.2E-02	3.2E-03	3.2E-03	3.2E-03	3.2E-03	3.2E-03	
Np	4.1E-01	4.1E-01	4.1E-01	4.1E-01	1.4E-02	1.4E-02	1.4E-02	1.4E-02	1.4E-02	
Diat. Earth (DE)	6.0E+02	6.0E+02	6.0E+02	6.0E+02	2.1E+01	2.1E+01	2.1E+01	2.1E+01	2.1E+01	
Isotopes decayed to 10/1/90, (Ci/MTU)										
90Sr/Y	8.4E+01	8.4E+01	8.4E+01	8.4E+01	2.9E+00	2.9E+00	2.9E+00	2.9E+00	2.9E+00	
137Cs/Ba	1.1E+01	1.1E+01	1.1E+01	1.1E+01	2.9E+03	2.9E+03	2.9E+03	2.9E+03	2.9E+03	
106Ru/Rh	1.0E+00	1.0E+00	1.0E+00	1.0E+00	3.6E+01	3.6E+01	3.6E+01	3.6E+01	3.6E+01	
144Ce/Pr	6.3E+00	6.3E+00	6.3E+00	6.3E+00	2.2E-01	2.2E-01	2.2E-01	2.2E-01	2.2E-01	
MTU/batch	7.5	22.6	22.6	22.6	7.5	7.5	7.5	30.1	30.1	30.1

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Table A-2. MTU Basis  
Material Balance Table  
20 vol% Settled Solids Feed

Component	X7.	X8.	X9.	X10.	X11.	X12.	X13.	X14.	X15.	X16.
(mol/MTU)										
OH-	3.5E+01			2.2E+02						6.6E+02
F-	3.0E+00									
NO2-	1.5E+01									
NO3-	5.9E+01	1.9E+02	1.7E+02		5.3E+02	5.0E+02		9.7E+01		
SO4-2	5.2E+00									
CO3-2	7.9E+00									
Na+	1.7E+02		1.3E+02	2.2E+02		7.1E+01		5.3E+00		6.6E+02
Al	1.6E+01		4.0E+00			1.4E+00		1.0E-01		
Cr	3.9E-01									
Fe+3	2.0E-03									
Sr	1.3E-03									
Zr	1.3E-03									
Cs	3.6E-04		2.5E-03			5.7E-01		4.3E-02		
K	3.7E+00		8.6E+00			8.0E+00		6.0E-01		
Rb	8.9E-05		6.2E-04			1.4E-01		1.1E-02		
U	1.2E-04									
(g/MTU)										
TOC	1.9E+01									
Pu	7.7E-05									
Am	7.7E-05									
Np	3.4E-04									
Diat. Earth (DE)	4.9E-01									
Isotopes decayed to 10/1/90, (Ci/MTU)										
90Sr/Y	6.9E-02									
137Cs/Ba	1.6E+00		1.1E+01			2.6E+03		1.9E+02		
106Ru/Rh	8.6E-01									
144Ce/Pr	5.2E-03									
MTU/batch	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.1

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Table A-2. MTU Basis  
Material Balance Table  
20 vol% Settled Solids Feed

Component	X17.	X18.	X19	X20.	X21.	X22.	X23.	X24.	X25	X26.
(mol/MTU)										
OH-	7.3E+02		2.4E+02	2.6E+03						
F-				1.3E+02						
NO2-				6.2E+02						
NO3-				2.6E+03	1.1E+02	5.4E+02	4.5E+02	7.5E+01	1.9E+02	1.9E+02
SO4-2				2.2E+02						
CO3-2				3.3E+02						
Na+	7.3E+02		2.4E+02	8.3E+03		7.6E+01			7.6E+01	7.6E+01
Al				6.7E+02		1.5E+00			1.5E+00	1.5E+00
Cr				1.6E+01						
Fe+3				8.3E-02						
Br				5.2E-04						
Zr				5.5E-02						
Cs				1.7E-02		6.1E-01			6.1E-01	6.1E-01
K				1.6E+02		8.6E+00			8.6E+00	8.6E+00
Rb				4.3E-03		1.5E-01			1.5E-01	1.5E-01
U				5.7E+00						
(g/MTU)										
TOC				8.1E+02						
Pu				3.2E-03						
Am				3.2E-03						
Np				1.4E-02						
Diat Earth (DE)				2.1E+01						
Isotopes decayed to 10/1/90, (Ci/MTU)										
90Sr/Y				2.5E+00						
137Cs/Ba				7.8E+01		2.8E+03			2.8E+03	2.8E+03
106Ru/Rh				3.6E+01						
144Ce/Pr				2.2E-01						
MTU/batch	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.1

Table A-2. MTU Basis  
Material Balance Table  
20 vol% Settled Solids Feed

Component	C1.	C2	C3	C4.	C5.	C6.	C7.	C8.	C9	C10.
(mol/MTU)										
OH-	1.1E+02	4.4E+00	4.4E+00	4.4E+00	4.4E+00	3.1E+00		1.3E+00		
F-										
NO2-		1.9E+02	1.9E+02	1.9E+02	1.9E+02	1.4E+02		5.6E+01	1.3E+01	1.2E+01
NO3-										
SO4-2										
CO3-2										
Na+	1.1E+02	1.9E+02	1.9E+02	1.9E+02	1.9E+02	1.2E+02		3.5E+01		9.6E+00
Al		1.5E+00	1.5E+00	1.5E+00	1.5E+00	1.4E-02		5.6E-03		4.0E-01
Cr										
Fe+3										
Sr										
Zr		6.1E-01	6.1E-01	6.1E-01	6.1E-01	8.0E-03		2.9E-03		8.8E-03
Cs		8.6E+00	8.6E+00	8.6E+00	8.6E+00	5.5E+00		2.3E+00		4.3E-01
K		1.5E-01	1.5E-01	1.5E-01	1.5E-01	2.0E-03		8.3E-04		2.2E-03
Rb										
U										
(g/MTU)										
TOC										
Pu										
Am										
Np										
Diat Earth (DE)										
Isotopes decayed to 10/1/90, (Ci/MTU)										
90Sr/Y		2.8E+03	2.8E+03	2.8E+03	2.8E+03	3.6E+01		1.5E+01		4.0E+01
137Cs/Ba										
106Ru/Rh										
144Ce/Pr										
MTU/batch	30.1	30.1	30.1	30.1	271.1	271.1	271.1	271.1	271.1	271.1

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Table A-2. MTU Basis  
Material Balance Table  
20 vol% Settled Solids Feed

Component	C11.	C12.	C13.	C14.	C15.	C16.	C17.	C18.	C19.	C20.
(mol/MTU)										
OH-	1.5E+01						1.1E+02	8.0E+01		2.7E+01
F-										
NO2-										
NO3-		7.3E+01	6.8E+01		6.8E+00					
SO4-2										
CO3-2										
Na+	1.5E+01		6.9E+00		1.4E+00		1.1E+02	8.0E+01		2.7E+01
Al			8.8E-01		1.8E-01					
Cr										
Fe+3										
Sr										
Zr										
Cs			4.9E-01		9.9E-02					
K			3.6E-01		7.2E-02					
Rb			1.2E-01		2.5E-02					
U										
(g/MTU)										
TOC										
Pu										
Am										
Np										
Diat. Earth (DE)										
Isotopes decayed to 10/1/90, (Ci/MTU)										
90Sr/Y										
137Cs/Ba			2.2E+03		4.5E+02					
106Ru/Rh										
144Ce/Pr										
MTU/batch	271.1	271.1	271.1	271.1	271.1	271.1	271.1	271.1	271.1	271.1

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Table A-2. MTU Basis  
Material Balance Table  
20 vol% Settled Solids Feed

Component	C21.	C22.	C23.	C24.	C25.	C26.	C27.	C28.	C29.	C30.
(mol/MTU)										
OH-	1.3E+02								2.7E+03	
F-									1.3E+02	
NO2-									6.2E+02	
NO3-	2.0E+02	1.2E+01	7.5E+01	6.4E+01	2.0E+02	2.2E+01	2.2E+01	2.2E+01	2.8E+03	
SO4-2									2.2E+02	
CO3-2									3.8E+02	
Na+	2.9E+02		8.2E+00			8.2E+00	8.2E+00	8.2E+00	8.6E+03	
Al	4.2E-01		1.1E+00			1.1E+00	1.1E+00	1.1E+00	6.7E+02	
Cr									1.6E+01	
Fe+3									8.3E-02	
Sr									5.2E-04	
Zr									5.5E-02	
Cs	2.0E-02		5.9E-01			5.9E-01	5.9E-01	5.9E-01	3.7E-02	
K	8.2E+00		4.3E-01			4.3E-01	4.3E-01	4.3E-01	1.7E+02	
Rb	5.0E-03		1.5E-01			1.5E-01	1.5E-01	1.5E-01	9.4E-03	
U									4.9E-03	
(g/MTU)										
TOC									8.1E+02	
Pu									3.2E-03	
Am									3.2E-03	
Np									1.4E-02	
Diat. Earth (DE)									2.1E+01	
Isotopes decayed to 10/1/90, (Ci/MTU)										
90Sr/Y									2.9E+00	
137Cs/Ba	9.1E+01		2.7E+03			2.7E+03	2.7E+03	2.7E+03	1.7E+02	
106Ru/Rh									3.6E+01	
144Ce/Pr									2.2E-01	
MTU/batch	271.1	271.1	271.1	271.1	271.1	271.1	271.1	271.1	40.4	40.4

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Table A-2. MTU Basis  
Material Balance Table  
20 vol% Settled Solids Feed

Component	C31.	C32.	C33.	C34.
(mol/MTU)				
OH-	2.7E+03	2.7E+03	2.7E+03	
F-	1.3E+02	1.3E+02	1.3E+02	
NO2-	6.2E+02	6.2E+02	6.2E+02	
NO3-	2.8E+03	2.8E+03	2.8E+03	
SO4-2	2.2E+02	2.2E+02	2.2E+02	
CO3-2	3.3E+02	3.3E+02	3.3E+02	
Na+	8.6E+03	8.6E+03	8.6E+03	
Al	6.7E+02	6.7E+02	6.7E+02	
Cr	1.6E+01	1.6E+01	1.6E+01	
Fe+3	8.3E-02	8.3E-02	8.3E-02	
Sr	5.2E-04	5.2E-04	5.2E-04	
Zr	5.5E-02	5.5E-02	5.5E-02	
Cs	3.7E-02	3.7E-02	3.7E-02	
K	1.7E+02	1.7E+02	1.7E+02	
Rb	9.4E-03	9.4E-03	9.4E-03	
U	4.9E-03	4.9E-03	4.9E-03	
(g/MTU)				
TOC	8.1E+02	8.1E+02	8.1E+02	
Pu	3.2E-03	3.2E-03	3.2E-03	
Am	3.2E-03	3.2E-03	3.2E-03	
Np	1.4E-02	1.4E-02	1.4E-02	
Diat. Earth (DE)	2.1E+01	2.1E+01	2.1E+01	
Isotopes decayed to 10/1/90, (Ci/MTU)				
90Sr/Y	2.9E+00	2.9E+00	2.9E+00	
137Cs/Ba	1.7E+02	1.7E+02	1.7E+02	
106Ru/Rh	3.6E+01	3.6E+01	3.6E+01	
144Ce/Pr	2.2E-01	2.2E-01	2.2E-01	
MTU/batch	40.4	40.4	40.4	40.4

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